Persistence of Inequality after Apartheid: Assessing the Role of Geography and Skills

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Abstract

South Africa remains one of the most unequal countries in the world, despite the formal end of Apartheid in 1994. This paper develops and quantifies a model with spatially segregated residential, educational, and labor markets to examine the persistence of inequality in South Africa. We explore the role that Apartheid-era policies of racial segregation, particularly the establishment of "Townships" for non-White urban populations, have played in sustaining high levels of inequality. Our model incorporates heterogeneous agents, incomplete markets, and endogenous choices regarding savings, education, and occupation in a dynastic overlapping generations framework. Using household-level data spanning both the Apartheid and post-Apartheid periods, we establish key empirical facts about inequality in modern South Africa and calibrate the model accordingly. The model provides insights into the mechanisms by which geography and segregated educational and labor opportunities contribute to long-term inequality. We then assess the extent to which these standard economic forces account for the observed patterns of inequality and explore counterfactual scenarios to evaluate policy interventions.

Keywords: Township, Dual Economy, Inequality, Segregation, Human Capital.

JEL Codes: D5; D63; E24; J62; O11; O18; R23.

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1 Introduction

Black South Africans were largely denied economic opportunities during the period of structured Apartheid, which spanned five decades (starting in the late 1940s and being dismantled in 1994).¹ This systematic racial segregation resulted in South Africa being one of the countries with the world's largest income and wealth inequality. Perhaps surprisingly, despite the introduction of democracy in 1994, inequality in South Africa has remained staggeringly high (Chancel et al., 2021). This paper explores to which extent educational, residential, and labor choices account for this persistence in inequality, focusing on spatial segregation along these dimensions. We aim to shed light on whether these "standard" economic forces can rationalize South Africa's path since Apartheid or additional frictions, potentially related to a race, are required to explain inequality patterns observed in the data along various dimensions.

In this paper, we examine how policy decisions regarding urban relocation during Apartheid determine the country's economic development path until today. We investigate to which extent spatial segregation plays a central role in understanding the persistence of inequality. We emphasize the role played in the process by "Townships" – urban living areas that, under Apartheid, were reserved for non-Whites and were built on the periphery of towns and cities. Townships imply not only residential segregation from the rest of the city, but also physical segregation in educational and labor markets. We use a dynamic, general-equilibrium quantitative model to study the interaction between spatial segregation and educational, housing, and productive investments. Through the lens of our model, we assess to which extent the high level of inequality in present-day South Africa is accounted for by the slow transition path to a post-Apartheid equilibrium without race discrimination. This exercise allows us to shed light as to whether other factors, such as government policies or lack thereof, as well as persistent racial discrimination, might still affect the development path of South Africa after its first democratic election. Through counterfactual analysis, we explore how to turn cities that were substantially reorganized under the Apartheid period to privilege the White minority into places of real opportunity for everyone.

Apartheid's legislation system enforced segregation of residential areas by classifying the population of South Africa into different racial and ethnic groups.² It also introduced a brutal system of forced removals and strict control of population movement. Black population was not allowed to work or reside outside of their ethnic group Homelands unless a pass for a given urban area was issued or they satisfied quite restrictive conditions specified in Section 10(1) of the Black Consolidation Act. Moreover, even within urban areas, the non-White population was segregated into different Townships based on their racial and ethnic classification. It was compulsory for people to live in the area that was designated for their ethnic group. In addition, such spatial segregation was accompanied by segregation of public goods provision,

¹Apartheid refers to the period characterized by the harsh, institutionalized system of racial segregation in South Africa from 1948 to the early 1990s. More details on the historical context of Apartheid period are in Section 2.1.

²In this paper, we have little choice but to follow the racial classification used in South Africa during the period of Apartheid. Those groups were defined by the Population Registration Act of 1950: Black (sometimes also referred as Native, Bantu, or African), White, Coloured, and Indian. One can find the term 'Black' being used to refer to the entire non-White group in some contexts. In this paper, we combine Black, Indian, and Coloured groups as 'non-White'. We also use capital letters to highlight this particular use.

like education, and labor market restrictions.

Although Apartheid was formally abolished thirty years ago, its legacy persists over time and still continues to shape the South African economy. According to 2011 Census data, 65 percent of population residing in metropolitan areas lived in Townships. Importantly, more than 75 percent of Black population still remained in Township areas in 2011, while the share of White population residing in Townships is negligible. Overall, the conditions of households living in Townships barely changed since the period when the first democratic elections took place. Not only households residing in Townships are (were) poorer compared to the urban population, but also the growth of their income is (was) substantially slower. For example, the average income in a city was 2.4 times larger than average income in a Township in 1996, while in 2011, this figure was 4.5. Moreover, the real income of people residing in Townships didn't improve since the end of Apartheid, while we observe real growth of income for those residing in the cities. Similar patterns are observed in education, especially at the college level (the share of population with higher education is roughly five times larger in a city). At the same time, income and educational gap between Black and White population since Apartheid shrank. These facts together suggest that spatial segregation is an important dimension of inequality dynamics in South Africa and inter-generational mobility. In this paper, we explore the role of such spatial segregation in education and labor markets as drivers of inequality persistence in a heterogeneous agent model with imperfect financial markets, endogenous savings, educational and occupational choices.

Our paper starts by documenting that spatially segregated cities designed during the Apartheid period still shape economic development of South Africa. We leverage numerous data sources we document a number of stylized facts about evolution of inequality in South Africa since the end of Apartheid period. First, we show that while inequality during Apartheid was primarily driven by difference in income between Blacks and White, post-Apartheid inequality persistence is due to rising inequality within Black population. Moreover, inequality between racial groups in the last thirty years has declined. Second, we explore various socioeconomic characteristics of individuals and households in South Africa to shed light on the dimensions that are associated with income divergence, particularly for Black population. We find that increase in college attainment among Blacks combined with very high return to higher education substantially increase income gap between Blacks. Interestingly, we find that while returns to entrepreneurship are high for White population, this channel is somewhat muted for Black population. This suggest that additional market imperfections that interact with labor market opportunities might play a role. Finally, we find that income gap between Blacks still residing in Townships and those moved to the City is increasing over time.

Motivated by our empirical findings, we develop a model to quantify the role of spatial segregation in education and labor markets as drivers of inequality persistence in an environment with imperfect financial markets, endogenous saving, educational and occupational choices. More specifically, we build a heterogeneous-agent spatial general equilibrium model that accounts for imperfections in the credit market, as well as the trade-off between living, working, and studying in a Township or in a City. The model features overlapping generations of households composed of a parent and a child. Households jointly decide on consumption and educational and productive investments. During Apartheid, non-White households are forced to live and educate their children in Townships and commute to the City to work. After Apartheid, households are allowed to choose the location where they live, study and work freely.

In addition to the spatial dimension, our model incorporates a rich environment for production and education. We believe that such dimension of a model enables us to capture important economic mechanism that affect the speed of transition, such as asset accumulation, human capital accumulation, as well as the trade off between productive and educational investment. Households' occupational choices include working as low-skill, high-skill workers and becoming entrepreneurs. In turn, we allow entrepreneurs to operate two different technologies (modern and traditional) to capture the vast differences in firm characteristics observed in the data. Primary and secondary schooling is mandatory and free for all children, but its quality is differentiated across locations. Difference in school quality is set exogenously to capture the differences in schooling inputs observed in the data, such that human capital after secondary school depends on a child's talent and a school location. Children who do not attend college can work as low-skill workers during part of their youth, while attending college entails a monetary and a time cost. Moreover, returns to college depends on the level of human capital obtained during school years, so that there are additional benefits of attending better school quality. We assume that, high-skilled jobs are limited only to college graduates. In addition, college education enhances entrepreneurs' productivity of those who use modern technology, but not traditional one.

In the presence of imperfect markets, location, human capital, and productive investments are jointly decided by the household. Thus, segregation, entrepreneurship, and human capital decisions are intertwined. We use our quantitative model to assess the importance of these different interactions. Our quantification strategy consists of four steps. First, we calibrate an "Apartheid" steady state to match the South African economy in the early 1990s, relying on the 1991 Census data. Second, we compute a counterfactual "race-blind" steady state in which we remove all racial restrictions. Third, we compute the transition between the two and assess the evolution of inequality along the transition path relative to the one observed in the data. We also validate the model by exploiting exogenous variation in distance from various Townships to the City. Finally, we use the model to identify other mechanisms that shape evolution of inequality in South Africa today and not captured by standard economic forces by comparing model outcomes and the data. We conclude by discussing the role of public policies that can help mitigate negative consequences of the past discriminatory policies and bring economy faster to a new lower inequality steady state.

PARAGRAPHS ABOUT MODEL PART Our model is able to capture salient facts of the Apartheid and democratic eras in South Africa. It implies a protracted entry of Blacks into college first, and then into modern entrepreneurship. This implies an inverted U-shape pattern of the evolution of within Black inequality. We also find that spatial segregation plays a substantial role in slowing down the convergence between Blacks and Whites, and that reducing commuting costs can be a powerful lever to speed up access to opportunity.

While the main goal of this project to explain persistence of inequality in South Africa after abolishment of highly discriminatory policies, we believe that our setting allows us to draw more general conclusions. While racial segregation during Apartheid in South Africa was among the most extreme forms of racial segregation during the twentieth century. However, present-day South Africa is hardly alone in its struggle with continuing racial inequalities in wealth, income, and opportunity. For example, racial and income segregation is a salient feature of many American cities, affecting access to economic opportunities for many families and, in turn, impacting inter-generational mobility and inequality (Chetty et al., 2016, Chetty et al., 2018). Moreover, during colonial times, similar segregation policies were applied in other developing countries. Examples include, but are not limited to, Windhoek – the capital of Namibia – that was under South African control, as well as Salisbury in Zimbabwe. Last but not least, Townships have many parallels with slums, which are salient features of many urban areas across the globe. At the same time, South African case is unique in city context as transportation costs between Townships and Cities are extremely high. According to some estimates, average transport costs for those who are employed in South Africa can be as large as 57% of net wages when time to commute is accounted for (Shah and Sturzenegger, 2023). In this context, more relevant application of our work might be analysis between more segregated areas, like South and North of Italy or rural and urban areas.

Related Literature WE NEED TO UPDATE LITERATURE There is a large theoretical and, to a lesser extent, quantitative literature focusing on the relationship between inequality and local externalities, starting from the seminal works by Benabou (1993), Durlauf (1996), and Fernandez and Rogerson (1998) who pointed out the quantitative importance of segregation in the provision of education for the persistence of inequality. A recent empirical literature including Chetty et al. (2016), and Chetty and Hendren (2018a,b), has garnered substantial attention by using US administrative data to show that there are substantial effects of children's exposure to different neighborhoods on their future income.³ Motivated by these findings, Fogli and Guerrieri (2019) build a quantitative general equilibrium model and find that segregation and inequality amplify each other because of local spillovers that affect returns to education based on a calibration using recent US data.⁴ Relatedly, Eckert and Kleineberg (2019) study the effects of school financing policies using a residential and educational choice model where local spillovers generate residential sorting. They find that these local spillovers generate persistent effects on adult outcomes through local labor

³Chyn and Katz (2021) provide a summary of recent literature on the importance of neighborhoods for the economic and social outcomes of adults and children. In addition to the literature that focuses on city segregation, there are also papers that explore the consequences of high levels of segregation in a cross country setting. Alesina and Zhuravskaya (2011) show that countries where different linguistic and ethnic groups are more segregated across regions are characterized by significantly lower government quality.

⁴Durlauf and Seshadri (2018) explore the idea that larger income inequality is associated with lower intergenerational mobility, the "Gatsby curve."

market access and local human capital formation.⁵ Our paper incorporates the mechanisms of local human capital formation and fragmented markets highlighted by this literature into a heterogeneous-agent model a la Aiyagari with entrepreneurial choice in the context of South Africa.

A central question in our paper is whether Townships' economic and geographical segregation creates a poverty trap (or, at least, substantial amplification of bad fundamentals as in Buera et al., 2021), driven by low human capital accumulation, low levels of public and private investments, and persistent policy neglect by governments. In this sense, our project is related to Monge-Naranjo et al. (2018), who use a quantitative general equilibrium model to investigate the emergence and persistence of urban slums and calibrate it to Brazilian data. They propose a model with overlapping generations of individuals with different skills to investigate what are the effects of slums on human capital accumulation, structural transformation, urban development, and social mobility. Our paper also relates to Rivera-Padilla (2021), who builds a spatial general equilibrium model that takes into account individual selection and location differences in returns to education, productivity, and housing rents. However, in this paper, education is exogenous, and there are no financial frictions.⁶ Finally, this paper also speaks to the role of racial segregation on the socioeconomic outcomes as in Gregory et al. (2023) who study the forces maintaining racial segregation and their implications for the Black-White gap in college attainment.

Our paper also relates to the literature that has investigated the interaction between human capital and entrepreneurship investments in an incomplete-markets setting. Mestieri et al. (2017) study an environment with financial frictions in which dynasties of households face educational and entrepreneurial investments in the context of Mexico and the Progresa/Oportunidades program and argue that the interaction between these two channels plays an important role in accounting for inequality and intergenerational mobility.⁷ Different from them, we feature spatial segregation and also a housing margin. Our paper also broadly relates to the literature that explores quantitatively the relationship between economic development and market proximity following the seminal works of Redding and Venables (2004) and Redding and Sturm (2008),⁸ and more recently, among others, by Tsivanidis (2018) and Bryan and Morten (2019).

⁵Regarding determinants of neighborhood formation, our paper also relates to Lee and Lin (2018), who study the role of natural amenities in neighborhood dynamics in the US, and Heblich et al. (2021) who look at the effects of temporary disamenity during the Industrial Revolution in England.

⁶Hsiao (2022) quantifies the long-run aggregate and distributional effects of Indonesia's school construction programs, one of the largest in history, using a spatial equilibrium model. In the model in which graduates migrate and seek employment nationally. The model is used to show how spatial concerns apply to educational infrastructure via migration, and provides new evidence on endogenous human capital formation in a spatial setting. Cavalcanti et al. (2019) study how urban poverty, rural-urban migration and land use regulations can impact the growth of slums.

⁷Castro and Sevcik (2016) also study a similar environment and study how these frictions affect aggregate productivity of an economy.

⁸This mechanism has been studied extensively theoretically, see Fujita et al. (2001) and Baldwin et al. (2005) for syntheses of theoretical research

2 Stylized Facts on Inequality in South Africa

In this section, we use data collected pre-, during, and post-Apartheid to establish stylized facts about the development of inequality in South Africa across time and space. We start by describing the historical context of segregation in South Africa, focusing on how Townships were used as tools of systematic segregation and control. An overview of the data used in our analysis follows. We then proceed with documenting important aspect of inequality evolution along different dimensions. Specifically, we examine the role of educational, occupational, and residential choices in accounting for the persistence of inequality. These insights inform our modeling approach and guide the quantitative analysis.

First, we demonstrate how spatially segregated cities became a defining feature of the South African geography during Apartheid and continue to influence the country's economic development. Next,

2.1 Historical Background: Emergence of Townships in South Africa

During the strict Apartheid era that began in 1948, the ruling Nationalist Party sought total social, political, and spatial separation between White and non-White people in South Africa—which included Blacks, Coloured and Asians. However, the White economy relied heavily on cheap African labor, as Whites were reluctant to perform manual work or lose their African servants. This combination of separation goals and dependence on African labor led to several organizational approaches in the country, as described in Desmond (1971): i) African self-development in separate rural "Homelands" or Bantustans; ⁹ ii) establishing White industries near Bantustans to source labor; iii) clearing smaller African residential areas, known as "Black spots," within White areas and consolidating the African population into Bantustans; iv) reducing the African population in White urban areas through influx control; and v) achieving complete segregation in all aspects of life for White and non-White individuals in White areas where non-Whites lived or worked. This paper primarily focuses on the role of the *urban* relocation processes and migration control centered around the creation of Townships¹⁰, which typically occurred in White areas outside of former rural "Homelands."¹¹ Below we briefly describe the key aspects that affected formation and development of townships before independence in 1994.

South Africa's urban population grew by 50 percent during the 1940s due to land dispossession from Black South Africans through various land acts and the increased mechanization of agriculture.¹² As a result of rapid urbanization and increasing opposition to racist policies, the Apartheid government passed

⁹The terms "Homeland," or "Bantustant" (also "Reserve" in pre-Apartheid period) have been officially applied to the African areas by the central government in South Africa. They refer to the ethnic political constructions that have been created based on former reserves: Transkei, Ciskei, KwaZulu, Qwa Qwa, Bophuthatswana, KwaNdebele, Kangwane, Lebowa, Gazankulu, and Venda. The map of South Africa during Apartheid is in Figure A1.

¹⁰SPP (1983) define Townships as "Residential areas set aside for African, Indian or Coloured occupations, usually situated adjacent to or within commuting distance of a White urban area on which they are economically dependent. Conditions in these areas vary, but generally formal housing is provided for rent, and sometimes for sale."

¹¹More details on the historical context that resulted in one of the most brutal segregation policies in the history of humankind can be found in Section **B** in the Appendix and the references therein.

¹²Based on the Census data, the Black urban population had risen from 1.7 million in May, 1946 to 2.3 million in June 1951.

legislation that formed the legal basis for forceful internal resettlement of non-Whites. First, the Black (Urban areas) Consolidation Act of 1945 highly restricted the number of Africans allowed to stay in White urban areas.¹³ Second, the system categorized the population along narrow ethnic lines.¹⁴ Third, the Group Areas Act of 1950 and Prevention of Illegal Squatting Act of 1951 provided the legal foundation for separating Blacks (also further divided based on ethnicity used in the Bantustan policy), Coloureds and Indians into different segregated urban Townships outside of the core of cities and forcefully removed people from informal settlements according to their racial classification. Finally, the Bantu Authorities Act of (1951) and the Bantu Resettlement Act (1954) created ten separated ethnic Homelands, or Bantustans, that became the destination of large scale removals of people.

While there was extensive development of Townships initially, from 1960 their development slowed down, and in 1967 the government stopped Township development outside the Homelands. At the same time, starting in the 1960s there was a massive deproclamation of existing African Townships and incorporation of Townships into the nearest Bantustan, through relocation or redrawing of boundaries.¹⁵ In addition, despite all policy efforts to control movement, the 1970s experienced another period of urban migration resulting in informal developments occurring largely adjacent to existing Townships. Furthermore, as a result of civil unrest, external pressure, and internal economic forces segregation policies began to relax in the mid-70s.¹⁶ Instead, housing was used to force social differentiation of urban African population, as now one needed approved accommodation to be a legal resident. Formal racial zoning legislation was removed from the statute book on June 30, 1991. Overall, despite the fact that Townships changed significantly and little legal restriction remained in place by the time the first democratic elections took place in 1994, South African cities were and now are still structured by Apartheid as shown in the subsequent sections.

In particular, according to Davies (1981) the Apartheid City was structured in the following way: i) a dominant White central business district; ii) a White-owned industrial sector working as a communal working area and a buffer between segregated areas; iii) strictly segregated residential areas separated by buffer zones; iv) separation of Blacks onto the urban periphery and borders of Homelands.¹⁷ Moreover, the Apartheid period was characterized not only by spatial segregation, but also segregation in the provision of public goods. The Bantu Education Act (1953) introduced a separate education system for Black learners, and in 1959 separate universities were created for Black, Coloured and Indian population.¹⁸ In

¹³Only those who qualified under section 10 of the Act were allowed to reside in urban areas, i.e. those that were born in the area and have lived there continuously; those who worked continuously for one employed in the area for 10 years; those who lived lawfully and continuously in the area for 15 years; those who obtained special permission to stay longer than the regular 72 hours limit, but still no longer than one year (served as a basis for the migrant labor coming from Bantustans). Africans without Section 10 rights stayed in urban areas under the risk of arrest, conviction, and deportation.

¹⁴The Population Registration Act of 1950 codified the population into three groups: White, Coloured, or Black (Indians were added later). Every Coloured and Black person was further classified according to their ethnic or other group to which they belonged.

¹⁵In case the city was within 75 kilometers of a Bantustan, a Township was deproclaimed and people were moved to a new rural Township in a Bantustan.

¹⁶For example, the abolition of the Influx Control Act in 1986 repealed the Natives (Urban Areas) Act of 1923, which had controlled the movement of Blacks between urban and rural areas for over 50 years.

¹⁷Detailed description of the Township evolution timeline is provided in Table B3 in the Appendix.

¹⁸Almost all Universities for Blacks were located in Bantustans. The only exception was the University of Western Cape, which

addition, labor legislation limited access to high-skilled labor markets and specific jobs and occupations were reserved only for White people or, sometimes, Coloureds. For example, Blacks were prohibited to run their own business. Finally, as a result of the forced relocation of the Black population to Homelands, a massive pool of cheap migrant labor arose.¹⁹ Thus, Townships were segregated physically, socially, and economically from cities, which made Township residents isolated and poor as access to economic opportunities and urban amenities was very limited.

Finally, the Apartheid period was also characterized by almost no political rights and access to decisionmaking for Blacks, Coloureds, and Indians. First, Blacks didn't have any representation on City Councils and they were restricted to advisory roles in Township administrations. Second, planning, services, or rental rates within Townships were determined by the White administration as the Urban Bantu Councils established for the Townships had little de facto and de jure control (Smith, 1992). As a result of such power imbalances, the allocation of public goods was highly skewed towards White areas both in terms of quantity and in terms of quality.

Racial Segregation in Historical Perspective Before turning to our main motivating stylized facts, we demonstrate that the extent of racial segregation imposed by Apartheid was unprecedented even by South African historical standards. While most features of Apartheid – limited access to urban areas, racial segregation, and restricted regulation – were also present in the 19th and first half of the 20th centuries, the urban policy during Apartheid was more rigid, more systematic, and more vigorously implemented than urban policy in the preceding segregation era. During Apartheid, non-White South Africans were separated into different segregated urban Townships based on their race and, for the Black population further segregated based on ethnolinguistic differences wherever they were present. Not only was it compulsory for people to live in the area designated for their group, but also the location of the Township was determined by the White minority and the availability of some natural buffer zone. The typical structure of an urban area during Apartheid is shown in Figure A2.

We use data from Historical Population Censuses starting from 1911 to document the evolution of the racial composition of Metropolitan districts in South Africa. As shown in Figure 1, a dramatic increase in spatial sorting occurred during Apartheid, while periods before and right at the beginning of Apartheid were characterized by heterogeneous geographic allocation of population in terms of race.²⁰ Indeed, by 1951 fully racially homogemous districts became the most prevalent in the distribution of district by race composition. Furthermore, by 1980, more than 50 percent of all districts became racially homogenous.

was mostly available for Coloureds.

¹⁹Such labor mobility constraints may have further adversely affected the education of the Black population due to low expected returns.

²⁰Christopher (1990) shows similar patterns for urban areas by computing indices of segregation using Census data from 1911 to 1985.



Figure 1: Historical Race Distribution Across Districts: 1911 & 1991

Notes: Each plot depicts the distribution of the levels of maximum share of one racial group within one district. 100 percent implies fully homogeneous district in terms of racial composition. There are four racial groups used in the analysis: Whites, Blacks, Coloureds, and Indians. A similar picture is observed if the sample is restricted to the same geographical definition of individual districts (Figure A3).

Segregation in the last Apartheid-era Census The 1991 Census further reveals that racial mixing was rare under Apartheid, with Townships largely comprising racially homogeneous populations. Enumeration Areas (EAs)—the smallest geographical unit available in this Census, each typically containing around 220 households—showed minimal racial diversity (see Figure A4 in the Appendix). This segregation was further reinforced by ethno-linguistic zoning policies, resulting in a high concentration of households within each area speaking the predominant local language. Among Black populations, an average of 72.6% of households within an EA spoke the dominant language, compared to 40% across the entire population.²¹

The migration from Homelands to Townships after 1985 intensified housing shortages, driving the growth of informal settlements and perpetuating Apartheid-era spatial patterns. Consequently, by the 1990s, South African urban areas were still heavily shaped by Apartheid's legacy rather than proximity to economic opportunities. Urban development practices continued to isolate populations, with dense Townships situated far from employment centers. This spatial arrangement forced residents to rely on transportation and underscored the division between central, predominantly White neighborhoods and peripheral Black areas. Importantly, and what makes South African context somewhat unique, extremely large transportation costs between City's center and Townships implies importance of spatial structure beyond residential markets. Specifically, such high costs also translates into segregation in economic opportunities—access to education and jobs. As we show later in the paper, most Township residence are employed in the City core, which in the context of high transplantation costs has a substantial impact

²¹For the Black population, major languages include Zulu, Xhosa, South and North Sotho, Tswana, Tsonga, and Venda.

on households disposable income and, as a results, lowers the ability to make human or physical investment. According to Shah and Sturzenegger (2023), average transport costs for those who are employed in South Africa can be as large as 57% of net wages when time to commute is accounted for. This historical context forms the basis for our focus on comparing City centers and Townships, as well as our strategy for validating our model.

2.2 Urban Inequality in South Africa: Stylized Facts

We next document a number of stylized facts regarding the evolution of inequality in South Africa's urban areas starting from the final years of Apartheid until today. More specifically, we look at the trend in overall inequality, as well as the inequality across individuals and households conditional on a number of socioeconomic characteristics. Those stylized facts will guide our modeling choices in the next section.

2.2.1 Data

Our empirical analysis is based on the data from various sources. First, we use geospatial data of Townships to examine their role in today's economic outcomes. Second, we use a number of household surveys to examine how urban segregation policy during Apartheid affects today's economic outcomes of households. Third, we use Census data to examine the evolution of households' spatial allocation and dynamics of various economic outcomes during Apartheid and post-Apartheid. As this paper focuses on segregation policies in urban areas, we restrict our analysis to locations that belong to Metropolitan Municipalities or Districts. Below we briefly describe key aspects of the data.²²

Township Data Our main empirical analysis investigates the impact of Townships on various economic outcomes. To do that, we define a Township and then generate a variable that identifies Townships in the geographical space of South Africa according to this definition. The key challenge is the emergence of new Townships and informal settlements as a result of the urbanization process observed since the country's independence. To address this issue, we rely on information from various sources, including historical records and maps.

As a "broad" definition of a Township, we rely on the data from the SA Township Opportunity Atlas provided by AfricaScope. They define Townships as formal or informal urban residential areas where there is a predominance of previously disadvantaged people. In other words, residential areas where more than 80 percent of residents classify themselves as either Black, Coloured, or Indian. A similar definition of a Township is used in Lester et al. (2009), except that they exclude Townships that are located in former Bantustans. This broad definition includes not only Townships formed during the Apartheid period but also those formed post-independence and informal settlements.

 $^{^{22}}$ A more detailed description of data sources and variables used is in Section C in the Appendix.

To address concerns related to endogenous location choice of post-Apartheid Townships in our model validation exercise, we also construct a Township identifier using a "narrow" historical definition. For the narrow definition of a Township, we use historical records and maps to manually identify those formed as a result of an Apartheid segregation policy rather than as a result of the urbanization process that took place after the first democratic elections. In addition to separating historical and post-Apartheid Townships, we also identify Townships in the Metropolitan areas that are not included in the AfricaScope list but appeared in the historical maps. We do so for both definitions of Townships, but due to the lack of systematic records across the whole country, we focus only on Metropolitan areas, which accounted for 40 percent of all population in South Africa in 2011. We define "City" in our empirical analysis as any urban Metroarea that is not classified as Township.

Our list includes a total of 575 Townships using our broad definition for the entire country. For eight Metropolitan areas the list includes 232 Townships based on the broad definition, and 205 based on the narrow definition. In addition, we collect information on whether a Township belongs to a former Bantustan area as well as the name of the respective Homeland, the current and historical dominant ethnicity "classification" of a Township, and the distance to the nearest Metropolitan areas (including major cities).²³ The average distance of Townships in Metropolitan areas to the closest major city is 27 kilometers.

Household data For the data on household socioeconomic outcomes we rely on a number of sources. Our main analysis uses data from Population Censuses conducted around the end of the Apartheid period in 1991 and in a more recent period – 2011.²⁴ For the 1991 Census we are able to observe all individuals and their socioeconomic characteristics surveyed in South Africa and three independent Homelands – Bophuthatswana, Venda, and Ciskei.²⁵ To obtain geospatial information of the districts in the 1991 Census, we use the Giraut and Vacchiani-Marcuzzo (2009) database which harmonizes and interrelates over time the maps of the districts, provinces, and urban areas for South African localities from 1911 to 2001. We limit our sample to Metropolitan districts in 1991, excluding the ones that were located in the Orange Free State to ensure consistency of the Metropolitan locality definition between 1991 and 2011 and focus on the main urban areas only.²⁶ While the lowest level of geographical unit available in the 1991 Census is the Enumeration Area, we are only able to geolocate districts for this time period given geographical data availability. Therefore, we assume that all Black households reside in Townships and all Whites in the core of a city. Indeed, the share of different groups across Enumeration Areas depicted in Figure A4 represents a bimodal distribution with most of the mass being either at 0 or 100 percent indicating almost full racial segregation.

In Censuses conducted after the first democratic elections the lowest level of data aggregation that is

²³The list of Townships and their characteristics is available here.

²⁴The most recent Census in South Africa was conducted in 2022, but data are yet unavailable.

²⁵Data for Transkei are not available, but since we focus on major Metropolitan areas non of which are part of Transkei, this does not compromise our analysis.

²⁶Map of South Africa, including Homelands and Metroareas, using districts of '91 is depicted in Figure A5 in the Appendix.

available to researchers and enables mapping socioeconomic outcomes to Township variables is Enumeration Area (EA) for the 1996 Census, and Small Area Location (SAL) for the 2001 and 2011 Censuses. Those areas contain approximately 500-600 people on average. In the analysis, we focus on eight Metropolitan Municipalities, which account for 32 percent and 40 percent of the population in 1996 and 2011, respectively. To map EAs and SALs to the Township variables we use geolocation. In addition, using geographical data, for each EA and SAL we compute the distance to the closest city of population 100,000 people or more, as well as to the largest city in a given Municipality.²⁷ To ensure, that our mapping captures the spatial allocation of different ethnic groups during the Apartheid period we compute the share of non-White population in the non-Township part of Cities and Townships (Figure A6). Indeed, the SALs identified as Townships are predominantly non-White. In addition, the numbers computed using data from the 2011 Census, point to substantial persistence of segregation over time. First, the share of non-White population remains stubbornly high in Townships at almost 100 percent. Second, the share of non-White population in non-Township parts of the cities, while higher compared to 1996, remains well below the total share of this group in general population of those municipalities.

In addition, to compare outcomes obtained for 1991 Census with more recent data, we use individual level data, which is available for 10% of the Census data and is representative of the overall population. However, given the rich set of variables available for each individual, Statistics South Africa does not provide a sufficient level of geographic aggregation to map individuals to Township data due to confidentiality issues. Finally, to obtain more information on households' socioeconomic characteristics we look at data collected by Statistics South Africa in the General Household Surveys and Labour Force Surveys. Importantly, our empirical analysis as well as the structural model we focus only on Black and White population of South Africa. We do it for two major reasons. First, these two groups form the majority of Metropolitan population – 80 percent according to 1996 Census. Second, while Coloureds and Indians were severely discriminated during Apartheid period, their access to opportunities was less limited compared to Blacks and varied by region of South Africa.

Commuting data To obtain information on the location of work and school choices relative to the place of residence, as well as the time and cost of commuting we use representative household survey data collected by the City of Cape Town in 2013. The survey contains household and personal information on more than 22 thousand households. In addition to demographics, income and asset ownership, the survey records the addresses of residence and work or place of study. We geocode respective addresses using Google Geocoding API and map those addresses to our Township data. This allows us to obtain information on the model moments, such as the share of households that live in Townships and work or send their kids to school in the City, and whether distance and cost affect various socioeconomic outcomes

²⁷The amount of SALs in one Township ranges from 1 to 1442 (Soweto), while the median level is equal to 39 in studied Municipalities. An example of mapping of SALs to Township is provided in Figure A7 in the Appendix for Khayelitsha Township in the City of Cape Town Municipality.

of households. Finally, we use data collected as a part of the Project for Statistics on Living Standards and Development (PSLSD) in 1993 to estimate the cost of commuting to work during the Apartheid period used in our model estimation.

Education data We use data from the education datasets available in South Africa, mostly from the Department of Basic Education (DBE). The education data provide information on a number of characteristics, such as the number of students and teachers, for the universe of schools in South Africa across a number of years in the 2000s. In addition, the geographical location of schools is available, so we can identify whether the school belongs to a Township.²⁸

2.3 Urban Inequality in South Africa: Stylized Facts

We start our empirical investigation by documenting a number of stylized facts regarding the evolution of inequality in South Africa starting from the final years of Apartheid till today. More specifically we look at the trend in overall inequality, as well as the inequality across individuals and households conditional on a number of socioeconomic characteristics. Those stylized facts will guide our modeling choices in the next section.

1. Race and Inequality. Segregation policies introduced during Apartheid resulted in South Africa being characterized as a country with one of the highest levels of income and wealth inequality, which was primarily driven by the inequality across races. Despite the introduction of democracy thirty years ago and removal of all legal barriers in terms of residential, occupational, and educational choices for the non-White population, inequality in South Africa has remained staggeringly high and even increased since the end of Apartheid. At the same time, we observe that the income gap between races has been declining since the end of Apartheid as depicted in Figure A8 and documented in Chatterjee et al. (2023), suggesting that inequality within racial groups has been driving the recent increase in inequality. Indeed, as shown in Figure 2, all increase in income inequality between 1991 and 2011 is driven by increase in inequality within Blacks. Moreover, over this period of time income inequality between Blacks and White (and within Whites) has not changed, and for working population has even declined.

2. Education and Inequality. Apartheid policies generated substantial education gaps between the White and non-White population not only due to allocation of children into schools based on their race, with substantially lower amounts of funds available for non-White schools, but also due to limited opportunities for higher education for the non-White part of the population. By the end of the Apartheid period virtually no Black individual had a college degree.²⁹ At the same time, the return to higher education is extremely high in South Africa as depicted in Figure 3. While South Africa experienced some convergence in terms of educational levels between racial groups post-Apartheid, such high returns to tertiary education

²⁸Overview of available education datasets is provided in van Wyk (2017).

²⁹Some Universities existed for Black population during Apartheid, but almost all of them were located in Bantustans. The only exception was the University of Western Cape, which was mostly available for Coloureds.



Figure 2: Within and Across Race Income Inequality Evolution

Notes: Inequality is measured by Theil index, which is further decomposed into the part that is due to inequality between Blacks and Whites and within two races. Data is restricted to eight Metropolitan areas. The sample is restricted to employed household heads of working age (25-50). We observe similar picture if we use the entire population or only those with positive income from any sources (see Figure A9).

is among one of the major sources of rising inequality within the Black population (Figure 3b). In addition, the quality of school education depends on the location of the school, with schools in Townships being substantially worse. For example, learner to instructors ratio is 28.1 in City schools, compared to 34.1 in Townships schools.³⁰

3. Occupational Choice and Inequality. Next we look at the evolution of income dynamics based on the primary occupation of individual. We find substantial income difference between individuals who are employed compared to those who run their own business or are self-employed. Importantly, the gap is particularly pronounced for Whites, while there is only minor differences for Black entrepreneurs. At the same time the share of business owners among Blacks has increased as entrepreneurship was forbidden for this group during Apartheid. The difference in entrepreneurship premium across racial groups can be attributed to the difference in business size. According to the Labour Force Survey conducted in 2011, one third of Black entrepreneurs operated in the informal sector, while the same is true for only 6.5% of White entrepreneurs. Importantly, more than 70 percent of Black entrepreneurs are self-employed, with only 3.9% operating businesses with more than 10 employees. Such differences can be driven by educational differences or the presence of market imperfections, such as financial frictions.³¹ For White entrepreneurs the respective numbers are 34.3 percent and 20.9 percent. This suggests that it is important to differentiate large and small business owners when we look at the dynamics of inequality.

Additionally, we find that there is an important interaction between education and entrepreneurship as depicted in Figure A10 in the Appendix. Returns to entrepreneurship are substantial for Blacks, but

³⁰We use data on location, number of learners, and instructors for all public ordinary schools in South Africa in 2014.

³¹In the Census data, we can not distinguish between entrepreneurs with hired workers and those who are self-employed. But in the Labour Force Survey we observe that the majority of owners of larger firms have college education.



Figure 3: Income Dynamics across Racial Groups

Notes: Each plot represents the average annual nominal income of a given group of individuals. Markers for income by education and employment reflect the size of a given category within respective racial group. Data is restricted to eight Metropolitan areas. The sample is restricted to employed household heads of working age (25-50).

only if they have higher education. On the contrary, for those without tertiary education, income from self-employment, on average, is practically the same as for the wage job. The same does not hold for Whites, who earn more being an employer or self-employed on average for any level of education. The latter fact suggests that there might be present some market incompletness, for example financial or capital constraint, that prevents Black entrepreneurs with little financial wealth from realizing their potential.

4. Spatial Sorting and Inequality. Finally, we look at the difference of various groups based on the location of their residence. The comparison of current and historical urban maps suggest that modern urban areas are still to a large extent shaped by Apartheid's urban policies, not only location-wise but also with respect to a given ethnic group (Figure A11). Moreover, while some mixing takes places in urban cores, Townships remain almost entirely non-White as we emphasize in our data description Section. Regarding economic outcomes, the income gap between racial groups declined, while the income gap between those residing in a City and a Township substantially increased since the end of Apartheid as depicted in Figure 4a. We observe similar patterns in terms of educational outcomes (Figure A13).

The widening of income gaps between Cities and Townships, as well as the persistence of the racial composition in Townships, suggest that spatial sorting in post-Apartheid South Africa plays an important role in shaping the dynamics of inequality. Moreover, we find that the role played by Townships is not limited to residential choice, but also determines access to labor and educational markets. Using commuting data from the Cape Town area we document work and education location choices of individuals relative to the location of their residence. First, we find that while those residing in the City primarily work and study in the City as depicted in Table 1, the picture is strikingly different for those who live in Townships. Specifically, the majority of individuals residing in Townships commute to work in the City, but primarily

Figure 4: Real Income Dynamics across Locations



Notes: Each plot represents the average annual real income of a given group of individuals. Price index is normalized to 1 for year 1996. We difine "Black" Township, as the Township where majority of residents are Black. We use broad definition of Townships, but results are similar to a narrow one. Sample is restricted only to individuals with non-zero income. We report results for all population in Figure A12.

study in the Townships. Importantly, decomposing education by levels, Township residents mostly commute to the City for tertiary education (Table A1). Those results suggest that labor market and educational opportunities are different in Townships and Cities.

	Liv	ve in City	Live in Township	
Wor		education	work	education
Commute to City	93.2%	91.5%	72.9%	25.9%
Commute to Township	6.8%	8.5%	27.1%	74.1%

Table 1: Share of Individuals by Location of Home and Work/Education

Notes: If we restrict the sample to those 25-50 years old, the patterns for work do not change. Numbers are computed using data from the Commute Survey collected in the Cape Town area in 2013. We use the broad definition of Townships. Using the narrow definition of Townships results in even stronger patterns of those presented here.

Moreover, as we show in Table 2, for those residing in Townships the probability of working in the City, sending kids to school in the City or attending college in the City depends on the location of a given Township relative to the City, suggesting importance of distance in access to labor and education markets.

In Section 3, we incorporate the facts documented in this section into a general equilibrium macro model to better understand the contribution of each factor to inequality dynamics in South Africa. More specifically, guided by our findings, we incorporate spatial differences, educational choices, as well as occupational decisions in an environment with incomplete markets.

	All Com	muters	School Co	ommuters	College C	Commuters	Worker	Commuters
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dist. Closest City	-0.03*** (0.001)		-0.04*** (0.01)		-0.05** (0.02)		-0.02 (0.01)	
Dist. Cape Town		-0.03** (0.01)		-0.03* (0.02)		-0.06* (0.03)		-0.01 (0.02)
Individual Controls	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Observations R^2	14,771 0.062	14,771 0.061	4,425 0.024	4,425 0.019	533 0.043	533 0.040	9,813 0.002	9,813 0.001

Table 2: Probability to Commute to the City

St. err. in parentheses and clustered at SAL level. Individual controls are age, male dummy, household size, number of adults in the household, number of employed and a dummy for a "Black" Township of residence. In all regressions we use a dummy variable that equals to one if the individual commutes to city for school (3-4), college (5-6) or work (7-8). The regression only includes historical townships. Variables have been standardized to have mean zero and std. dev. of one. * p < 0.10, ** p < 0.05, *** p < 0.01

3 Model

Motivated by the previous empirical evidence, we build a heterogeneous-agent, incomplete-markets, overlapping generations, dynastic model with two locations, a Township and a City center. The model features occupational, spatial and educational choices. The economy is populated by households that are heterogeneous in terms of their race, wealth, educational level, innate talent, and location. The talent and education affect agents' productivity, which in turn determines their occupational choices. The location of a household affects access to schooling and working opportunities. Each household consists of one parent and one child who collectively make decisions. Each household decides on the parent's occupation – worker or entrepreneur, the child's level of education, and whether the child joins the labor force. Due to borrowing constraints, these decisions are not independent. Instead, they are jointly determined and the level of household assets plays a role in shaping these choices. Finally, the race of the household is of no fundamental economic significance: talent draws are independent of race. Still, race is used during Apartheid to discriminate against Black households, limiting their choices and opportunities. We therefore use race as a state variable to compare economies during and post-Apartheid.

3.1 Demographics, Life Cycle, Endowments and Preferences

Demographics and Life Cycle A population of mass one is composed of two types of households: Black, *B*, and White, *W*, with mass m_B and m_W , respectively. We denote race generically by *j*, i.e. $j \in \{B, W\}$. Each household consists of a kid, *k*, and a parent, *p*. In the subsequent period the kid becomes a parent and has a kid of his own, while the previous parent in the household dies. Thus, household size is constant and equal to two. In the benchmark model, we assume that childhood is between 0 and 25 years old, corresponding to when a kid receives his education. The parent phase is between 26 and 50 years old, corresponding

to the adult age when an agent works. We assume that no further education is possible during this time. When a kid becomes an adult and a new kid is born, the household jointly makes the occupational choice of the parent, the educational choice for the newborn kid, savings, and location decisions in that period.

Endowments Each agent is born with innate talent *z*. Innate talent is stochastic but persistent across generations. The logarithm of innate talent across generations follows a first-order autoregressive process

$$\log z_k = \rho \log z_p + \varepsilon,\tag{1}$$

where z_k and z_p are innate talents of a kid and a parent, respectively, $|\rho| < 1$ is the persistence of the talent process, and ε is a white noise term drawn from a random normal distribution with variance σ_{ε} , representing the idiosyncratic talent component. The innate talent of an individual is fixed over time. Finally, the race of an agent is of no consequence for innate talent: all newborn agents draw from the same talent distribution.

Each household is endowed with financial wealth, *a*. Financial wealth can be accumulated by households endogenously. We do not allow borrowing across periods, so financial wealth must be non-negative, i.e., $a \ge 0$. However, we allow for within-period borrowing, as we discuss below when describing financial markets.

Preferences Households derive utility *U* from goods consumption of the parent, c_p , and from goods consumption of the kid, c_k , according to

$$U = \lambda \frac{c_p^{1-\sigma}}{1-\sigma} + (1-\lambda) \frac{c_k^{1-\sigma}}{1-\sigma},$$
(2)

for $\sigma > 0$ and $\lambda \in (0, 1)$ denoting the Pareto weight of the parent.

Remark (*Aggregate representation of household preferences*). Let $c = c_p + c_k$ denote total household consumption. The allocation of consumption within the household maximizing Equation (2) subject to $c = c_p + c_k$ satisfies maximizing the following

$$U = \frac{c^{1-\sigma}}{1-\sigma} \left[\lambda^{\frac{1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}} \right]^{\sigma}.$$
(3)

Households are forward-looking and discount future per-period utility at rate $\beta \in (0, 1)$. To fix ideas, given the description of the model so far, we can establish that the total value of the utility of a household can be expressed recursively as

$$V(a, z_p, z_k, h_p) = \max_{\cdots} U(c_p, c_k) + \beta \mathbb{E}_{z'_k, \epsilon'} \left[V'(a', z'_p = z_k, z'_k, h'_p = h_k | z'_k, \epsilon') \right] + \chi \epsilon,$$
(4)

where variables with subscript *p* and *k* without prime denote characteristics of a parent and a kid at time *t*, respectively; and with a prime, at time *t* + 1. The term ϵ denotes a household-specific utility shock for living in a given location. This shock is received each period. The term $\chi > 0$ parametrizes the importance of this idiosyncratic shock. We come back to Equation (4) after having introduced the rest of the model elements and fully describe it.

Households are subject to the budget constraint

$$c_p + c_k + e_H + e_{educ} + a' \le a(1+r) + y_p + y_k,$$
(5)

where c_p and c_k are consumption of a parent and a kid in the household, respectively; e_H and e_{educ} are household expenditures on housing and education, respectively; a is the level of assets; and y_p and y_k are labor income of a parent and a kid, respectively.

3.2 Geography

There are two locations in the economy: Township and non-Township urban areas, denoted by $loc \in \{T, NT\}$. When a household decides where to live, they must purchase one unit of housing at price P_l .

Housing Supply The housing supply differs across locations. We assume an infinite housing supply in Townships, ensuring that the equilibrium price of housing is always zero. By contrast, following Hsieh and Moretti (2019), we assume an isoelastic housing supply in the non-Township urban area

$$HS_{NT,t} = \alpha_{NT,h} P_{NT,t'}^{\frac{1}{\gamma_h}}$$
(6)

with a parameter $\alpha_{NT,h} > 0$ and the parameter γ_h standing for the inverse elasticity of the housing supply.

Commuting costs If an agent supplies labor or obtains an education in a location that is different from where this household resides, the household incurs an additive commuting cost, τ .

Residence Preference Shocks Households experience idiosyncratic residential preference shocks. As already anticipated in (4), we introduce an additively separable utility shock to living in any given location. Each household independently draws this shock each period from a standard Gumbel distribution. This shock captures idiosyncratic reasons beyond our model for why households may desire to live in any given location. Note, however, that since these shocks are iid across locations and over time, this assumption does not introduce any reason for households to prefer on average one location over another. Moreover, we assume that this shock does *not* differ across household characteristics, such as race.

3.3 Technologies

Education Technology Schooling allows kids to increase their human capital given their innate talent and schooling choice. In terms of schooling, a household makes two choices: i) the location of a kid's school, $loc^{S} \in \{T, NT\}$; ii) whether to send a kid to college after finishing school or to let him join the labor force. It is mandatory for a kid to attend school, which is free irrespective of the school's location. Note, that if a household decides to send the kid to a school that is located not where the household resides, they must pay a commuting cost, τ . The human capital obtained by a kid of innate talent *z* after attending school in location $loc^{S} \in \{T, NT\}$ is

$$h^{s,loc} = z(\underline{h} + h^{NT} \mathbb{1}_{school} = NT), \tag{7}$$

for some exogenous parameter h^{NT} that reflects higher quality of schools in non-Townships .³²

College is only offered in non-Township urban areas and requires a college fee, P_c , paid by all households that decide to send their kids to college.³³ Kids that don't go to college can join the labor force as low-skilled workers in the location of their residence after finishing compulsory schooling. Colleges serve two purposes. First, college enables agents to be employed in high-skilled jobs. Second, college increases the level of human capital obtained during school

$$h^{c} = \left(h^{s,l}\right)^{\eta},\tag{8}$$

with $\eta > 1$. In the model, we assume that human capital affects the productivity of modern entrepreneurs and the wage of hired workers, as described below.

Production Technologies All firms in the economy produce a final good, which can be freely traded across locations and whose price is normalized to one. There are two technologies for production: modern and traditional. Modern technology employs both low-skilled and high-skilled workers, while traditional technology only employs low-skilled workers. An entrepreneur with human capital, *h*, operating a modern technology produces output according to

$$y_M(h) = A_e h k^{\alpha_M} \left(l_H^{\omega} l_L^{1-\omega} \right)^{\gamma_M}, \quad \text{with} \quad \alpha_M, \gamma_M, \omega \in (0,1),$$
(9)

 $\alpha_M + \gamma_M < 1$, and $A_e > 0$. The input l_i with $i \in \{H, L\}$ denotes the total number of effective units of high- and low-skilled labor used in production, and k denotes the amount of capital. An entrepreneur

³²Using data on schools characteristics in South Africa, we find that schools in Cities have lower student to teacher ratios, but at the same time this ratio does not vary across Townships based on their proximity to the city, so the quality difference is independent of the location of a Township relative to City, i.e. independent of τ . We used other functional forms for human capital accumulation when calibrating the model. The choice of the functional form was determined by the best match to the observed data.

³³The college fee is assumed to be exogenous, so that the supply of college is completely elastic with respect to its price. Households that reside in a Township also have to pay commuting cost, τ , to attend college.

operating traditional technology produces output according to

$$y_T(z) = A_e z k^{\alpha_T} l_L^{\gamma_T}, \quad \text{with} \quad \alpha_T, \gamma_T \in (0, 1),$$
(10)

with $\alpha_M > \alpha_T$ and $\alpha_T + \gamma_T < 1.^{34}$ Note that the traditional technology does not require high-skill workers, and it is less capital intensive (since $\alpha_M > \alpha_T$).³⁵

3.4 Occupational Choice, Financial Markets, and Household Problem

Occupational Choice At the beginning of each period, households choose whether the adult should operate their own business or work for an outside business as low- or high-skill worker and the location where he works or operates his business. Each firm is run by one entrepreneur. All occupational choices are mutually exclusive within period t.

The income of a hired worker, both low- and high-skilled, depends on the level of his human capital, so that he receives the wage per efficiency unit of the chosen occupation times human capital. A kid that is not in college joins the labor force as a low-skilled worker for the time period between school and adulthood *only*, while free to choose any occupation as an adult. This corresponds to 5 years in the model—a fifth of the time period. He receives 20 percent of the low-skill-wage in the location he resides, irrespective of the level of his human capital.

Financial Markets Agents have access to a perfectly competitive financial intermediary that receives deposits from households and makes loans to finance capital and college expenses. We assume that South Africa is a small open economy and that financial intermediaries can borrow or save without affecting the world interest rate, *r*. Competitive financial intermediation implies that loan contracts to finance college are made at a rate *r*, while loans to finance capital are made at a gross interest rate, $r^k = r + \delta$, where δ denotes the depreciation rate of capital.

We assume, however, that financial markets are incomplete. First, state-contingent bonds are not available, meaning that households do not have the opportunity to get insurance against kids' talent risk. Second, borrowing for consumption smoothing across periods is not allowed, i.e., $a_t \ge 0$. Finally, in the spirit of Moll (2014) and Buera et al. (2015), any amount of capital *k* and college expenses P_c that exceeds the current level of assets owned by a household must be financed before income realization. Due to the limited enforceability of debt contracts, the amount of household borrowing is limited by a collateral constraint on household's assets, *a*. Thus, the amount of capital and college spending are constrained and are thus not

³⁴Given the transition process for talent, to ease notation, we assume that $z \equiv e^z$ described in Section 3.1

³⁵It can be verified that the slope of profits at $\theta = 0$ is higher for the traditional technology, but that the derivative of profits in θ is increasing in α (i.e., there is a positive cross partial). This implies that, under perfect markets, for sufficiently large h(z), α_M would be preferred.

independent from one another. The tightness of the constraint is proportional to household's wealth:

$$k + P_c \le \lambda_k a, \quad \text{with} \quad \lambda_k \ge 1.$$
 (11)

Thus, households with low wealth levels desiring to run a firm or send their children to college may be prevented to do so due to borrowing constraints. Moreover, talented entrepreneurs with low levels of wealth might face a trade-off between firm expansion and the education for their kids.

Household Problem Having described what the occupational choices are and how financial markets operate, we can fully describe the household problem. Households maximize the discounted value of utility, as described in (4),

$$V(a, z_p, z_k, h_p) = \max_{c, a', loc_H, \text{educ}, loc_{\text{educ}}, \text{occ}, l^L, l^H, k} \left[\lambda^{\frac{1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}} \right]^{\sigma} \frac{c^{1-\sigma}}{1-\sigma} +$$
(12)

$$+\beta \mathbb{E}_{z'_k, \epsilon'_{l_H}} \left[V'(a', z_k, z'_k, h_k | z'_k, \epsilon') \right] + \chi \epsilon,$$

subject to the household budget constraint

$$c + e_H(loc_H) + e_{educ}(educ, loc_{educ}) + a' \le a(1+r) + y_p(occ, loc_{occ}, h_p) + y_k(educ, loc_H),$$
(13)

the credit constraint (11),

$$k + P_c \le \lambda_k a, \quad \text{with} \quad \lambda_k \ge 1,$$
 (11)

and a' > 0, where *c* denotes total household consumption, $c = c_p + c_k$, $loc \in \{T, NT\}$ denotes the two possible locations in the model, Township and non-Township, e_H denotes housing expenditures in location loc_H (a dichotomous decision, $loc_H \in \{T, NT\}$) and e_{educ} denotes educational expenditures which, as discussed, can be attending school in *T* or *NT* or college in *NT* and include any transportation costs, τ , associated with the education choice and its location relative to the location of the household residence. The income of the parent, y_p , is a function of the occupation of the parent (low-skill worker, high-skill worker, traditional entrepreneur or modern entrepreneur), the location where the parent works (Township or non-Township), and the level of human capital (except for traditional entrepreneur which depends on a raw talent). If the location of work is not that of the residence, an additively separable transportation cost τ is incurred. The child's income y_k is only positive if the child does not attend college. Appendix D spells out the problem in its full mathematical detail.

3.5 Market Clearing

Let $\mathcal{F}_t(a, z_p, z_k, h_p)$ denote the joint distribution of wealth, talent of a parent and a kid, and the level of human capital of a parent over all households at time *t*.

The labor market clearing condition Labor markets are segmented by skills and location. Therefore, labor market clearing conditions imply that labor demand for low- and high-skilled workers from entrepreneurs at each location should be equal to the supply of respective workers at each location. Abusing notation for each location and skill level, the labor market clearing condition is

$$\int_{occ=entrep} l_{loc,i} d\mathcal{F}_t(a, z_p, z_k, h_p) = \int \mathbb{1}_{occ=worker} h_i^l oc \mathcal{F}_t(a, z_p, z_k, h_p), \quad \forall i \in \{H, L\} \text{ and } loc \in \{T, NT\}$$
(14)

with the understanding that the indicator function also comprises whether a kid supplies labor and that h_i^l denotes the human capital of type *i* and location *l* that is relevant in each case.

The asset market clearing condition We assume that South Africa is a small open economy and takes interest rate as given, hence the asset market clears by receiving or supplying financial capital from or to the rest of the world.

The housing market clearing condition The total demand for housing in each location should be equal to the supply. Since we assume that supply of housing in Township is infinitely elastic, we only have housing market clearing condition for non-Township.

$$\int \mathbb{1}_{l=NT} d\mathcal{F}_t(a, z_p, z_k, h_p) = HS_{NT}$$
(15)

3.6 Competitive Equilibrium

Given the initial distribution of state variables $\mathcal{F}_t(a, z_p, z_k, h_p)$ and a sequence of wages for low- and highskilled labor in Township and non-Township, interest rate, and price of housing in non-Township urban area, $\{w_t^{L,T}, w_t^{H,T} w_t^{L,NT}, w_t^{H,NT}, r_t, P_t^{H,NT}\}_{t=0}^{\infty}$, the competitive equilibrium is given by a sequence of allocations $\{c_t^p(s), c_t^k(s), a_t(s), k_t(s), l_t^H(s), l_t^L(s)\}_{t=0}^{\infty}$, where $s \equiv (a, z_p, z_k, h_p)$, occupational choices $\{occ_t(s) = \{Worker^L, Worker^H, Entrepreneur^T, Entrepreneur^M\}_{t=0}^{\infty}$, educational choices $\{e_t(s) = \{School, College\}_{t=0}^{\infty}$, and choices of locations for residence, work and school $\{loc_t(s) = \{Township, non-Township\}_{t=0}^{\infty}$ such that: (i) households maximize utility by solving value function maximization problem subject to a budget constraint, within- and across-period borrowing constraints, (ii) the financial intermediary makes zero profit, $r_t^k = r_t + \delta$, and (iii) market clearing holds in all labor markets and housing markets.³⁶

³⁶All derivations, including some equilibrium outcome are in Section D of the Appendix. The computational algorithm is described in Section E.

Stationary competitive equilibrium A stationary competitive equilibrium requires that the joint distribution over the state space variables is a fixed point of the equilibrium mapping and that prices are constant over time,

$$\mathcal{F}(a, z_p, z_k, h_p) = \mathcal{F}_t(a, z_p, z_k, h_p) = \mathcal{F}_{t+1}(a, z_p, z_k, h_p) \quad \text{for all } t.$$

4 Calibration and Model Quantification

In this section, we present the quantification of our model. Our quantification strategy consists of several parts. First, we calibrate the model to a steady state that captures the South African economy at the end of Apartheid in the first half of the 1990s. The distinctive feature of the Apartheid regime is the severe restrictions it imposes on Blacks. Second, using the calibrated model, we compute a race-blind steady-state equilibrium in which all Apartheid restrictions are lifted. By construction, outcomes are independent of race in this steady-state. Third, we compute the transition from one steady state to another and investigate the evolution of the overall economy and that of Blacks and Whites along several dimensions. Finally, we use the model to identify other potential mechanisms that shape evolution of inequality in South Africa today and not captured by standard economics forces by comparing model outcome and the data. We also validate our model by looking at the dynamics of economic outcomes for various pairs of cities and Townships that differ in their distance to the city center exploiting exogeneity of this distance.

4.1 Calibration to the Apartheid Era

We start by describing the calibration strategy of our model to the Apartheid era. We assume that the economy is in a steady-state and calibrate it matching data during the first half of the 1990s. Importantly, we calibrate a variant of the model described above that incorporates the restrictions on the Black and White populations imposed during Apartheid.³⁷ To this end, we segment the population between Blacks and Whites. Both in the data and in the model, we do not focus on Coloureds and Indians due to the relatively small size of these groups and because these groups were subject to somewhat different treatment during Apartheid compared to Blacks.³⁸ To capture Apartheid's discrimination policies described in Section 2.1, we impose additional constraints relative to the model described in Section 3:

- Housing and education markets are completely segmented. The White population is restricted to live and study in Cities, while the Black population is restricted to live and study in Townships. Therefore, the residence preference shocks are irrelevant during the Apartheid era.
- 2. Blacks are not allowed to become entrepreneurs or high-skilled workers.

³⁷We use a steady state for our calibration as Apartheid spanned almost fifty years, and its seggregation policies had been imposed by decades by the 1990s.

³⁸The share of White and Black population was around 83 percent in urban areas if we restrict sample to the head of household of the age 25 to 50 years old.

- 3. Blacks are not allowed to attend college.
- 4. Blacks are excluded from financial markets.
- 5. Whites can only work in Cities.

These restrictions capture in a stylized way the policies during Apartheid South Africa and have substantial implications for the workings of our model.³⁹ Under Apartheid, the problem of Black households reduces to

$$V(a) = \max_{c,a'} \left[\lambda^{\frac{1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}} \right]^{\sigma} \frac{c^{1-\sigma}}{1-\sigma} + \beta \left[V'(a') \right], \tag{16}$$

subject to the household budget constraint

$$c+a' \le a(1+r) + \underline{h}z \cdot w_L + 0.2 \cdot w_L - 2\tau, \tag{17}$$

and $a' \ge 0$. Note that we can ignore the within-period borrowing constraint for Blacks because they are forbidden to access college or entrepreneurship. Moreover, there is neither an occupational choice problem, since they are forced to be low-skill workers, nor a location problem, since they are forced to be low-skill workers, nor a location problem, since they are forced to live and educate their offspring in Townships. Since Townships are assumed to have an infinitely elastic housing supply, the housing expenditure is zero.⁴⁰

By contrast, the problem of White households is less constrained. White households can freely choose their occupation and the education of their offspring – they are, however, constrained not to live in Townships, and face the borrowing constraints discussed in Section 3. While the full mathematical details of the household problem are relegated to Appendix D, we want to emphasize that given the Apartheid constraints, only White households can run businesses, work as high-skill workers, and enroll their offspring in college. In steady-state equilibrium, this creates a large gap in earnings and assets relative to Blacks by the end of Apartheid, as we document in the data. As a result, when all racial restrictions are lifted, a combination of different initial conditions and incomplete markets slows the transition to a new steady state.

To quantify the Apartheid steady-state, we need to specify twenty-two parameters. We take a hybrid approach to quantify our model. We take some of the more standard parameters from the literature, estimate some parameters from the data before simulating the model, and jointly calibrate the rest to match aggregate moments in the data. To this end, we mostly leverage the South Africa 1991 Census, which contains rich information, including individual and household identifiers, location, race, income, occupation, and education. In addition, given our assumptions on residence locations for each population group for

³⁹We observe in the data that during Apartheid the Black and White population did not reside in the same areas, almost no Black people had higher education or has been self-employed or employer as depicted in Figures A4 and A14.

⁴⁰For the Black population, the Apartheid era problem is a standard permanent income hypothesis partial equilibrium analysis. Abstracting from borrowing constraints, the Euler equation governing the path of consumption next period, c', is $\frac{c'}{c} = [\beta(1+r)]^{1/\sigma}$.

Param.	Value	Description	Source
σ	1.5	Coeff. Relative Risk Av.	Buera and Shin (2013)
λ	0.7	Household Pareto Weight	Krueger and Ludwig (2013)
ρ	0.47	Talent Persistence	Mestieri et al. (2017)
δ	0.06	Yearly Depreciation	Buera and Shin (2013)
γ_h	0.5	Housing supply inverse elasticity	Cavalleri et al. (2019)
γ_T	0.41	Labor Share Trad Tech	Mestieri et al. (2017)
α_T	0.20	Capital Share Trad Tech	Mestieri et al. (2017)
γ_M	0.41	Labor Share Modern Tech	Mestieri et al. (2017)
α_M	0.30	Capital Share Modern Tech	US estimates
ω	0.65	Low-skill Share in Mod. Wage Bill	Machin and van Reenen (1996)
κ	0.12	Variance location pref. shock	Gregory et al. (2023)

Table 3: Calibrated Parameters: Parameters Set Ex-ante

the Apartheid period, both house supply and housing price do not change equilibrium outcomes. Therefore, we set the housing supply to be equal to the share of White population and we set the price of housing to ensure equilibrium on the residential market.

Invariant parameters directly calibrated from the literature We take parameters relating to preferences directly from the literature. These preference parameters are assumed to remain stable over time. These are the coefficient of relative risk aversion, adults' Pareto weight in the utility function, talent persistence, the depreciation rate for capital, the variance of the location preference shocks, and the housing supply inverse elasticity.⁴¹ Table 3 summarizes them. In addition, we set the 25-year discount factor at 0.36, corresponding to an annual level of 0.96.

For the production technology, we calibrate the labor share to be twice the capital share as in Buera and Shin (2013) and use the calibrated results in Mestieri et al. (2017) that $\alpha + \gamma = 0.61$ for traditional entrepreneurs. Since modern entrepreneurship is assumed to be more capital intensive, we set α_M to 0.3 matching estimated in advanced economies. We also assume that labor intensity is the same for both types of entrepreneurs. Finally, we follow Gregory et al. (2023) to set our location preference shock, which is identical for all households, irrespective of their race.⁴²

Parameters directly estimated from the data We leverage household surveys conducted during and post-Apartheid to compute a number of parameters that we can directly match to parameters in the data. We set the share of Black population, m_B , in the model to be equal to 80 percent, which represents the share of households residing in Metropolitan Districts in the 2011 Census, where the head of household belongs to a Black population group and is between 25 and 50 years old.⁴³ We set the borrowing constraint

⁴¹We also set $\alpha_{NT,h} = 1$, so that $HS_{NT,t} = P_{NT,t}^{\overline{\gamma_h}}$.

⁴²We perform a sensitivity analysis to the value of κ in Section **F** in the Appendix.

⁴³The share of Blacks in Metropolitan areas was lower at the end of Apartheid period due to influx control compared to level in 2011. We use the latter to ensure that none of the transition results are not mechanically driven by higher share of Black population given differences in initial conditions across races. Importantly, using share as observed in 2011 should not impact our calibration

Parameter	Value	Description	Source
$ \begin{array}{c} m_B \\ \tau \\ \lambda_k \\ r \end{array} $	$80\% \\ 0.103 \cdot w_L \\ 1.87 \\ 2.5\%$	Share of HH where the head is Black Transportation cost Collateral constraint Real Interest Rate	Census (SA, 12011) PSLSD (SA, 1993) WB Enterprise Survey (SA, 2020) World Bank (1993)

Table 4: Parameters Directly Estimated using Household Data

to a value consistent to collateral to loan value of 115.4% obtained from the World Bank Enterprise Survey conducted in South Africa in 2020, $\lambda = 1.87$.⁴⁴ To set the value of transportation cost for those commuting from Township to the City we use data from Project for Statistics on Living Standards and Development (PSLSD) collected in 1993. We compute the average cost of commute to work incurred by Black heads of household relative to their income – 10.3%.⁴⁵ Finally, we set a 2.5% real interest rate *r*, which is the real interest rate of South Africa in 1993 according to the World Bank.⁴⁶ Table 4 reports the results.

Parameters calibrated by matching moments The rest of the parameters are internally calibrated by jointly matching moments that inform the remaining parameters values. To inform the parameters of the talent distribution, we use information on occupational choices of White population. To inform the production function of human capital, h and η , as well as the price of college, P_c , we leverage data on the share of high-skilled White entrepreneurs,⁴⁷ the ratio of income for college and non-college graduates, and the share of Whites with college degree. We also use information on the average income difference for workers with no college education who completed secondary school across Blacks and Whites to inform the parameter governing school difference across two locations, h^{NT} . As described above, most of the data moments capture variation within White population. This strategy allows us not to embed discriminatory policies into the model parameters coming from variation between Blacks and Whites during Apartheid and subsequently can impact the outcomes of race-blind equilibrium.

4.2 Race-Blind Steady State and Model Mechanics

After calibrating the Apartheid steady-state, we compute a race-blind equilibrium, in which we eliminate all race-related constraints described in the previous section. Thus, households freely choose their residence, occupation and child's education based on their abilities, assets and parent's education, independent of their race.

much as almost all moments we match are computed for White population, i.e. using variation within Whites.

⁴⁴We derive λ_k assuming that all households use credit up to their maximum value. The data from earlier surveys reports similar levels of collateral to loan value.

⁴⁵Those costs include only the monetary cost of commute, i.e. if individuals walk, the cost are equal to zero. In the data we also observe time spent on the commute, which can also be used to calibrate the parameter. ⁴⁶See https://data.worldbank.org/indicator/FR.INR.RINR?locations=ZA.

⁴⁷The share reflects the share of high-skilled entrepreneurs among all entrepreneurs. We define high-skilled entrepreneurs as employers or self-employed with income higher than high-skilled workers in the data.

Moments				Model Parameters		
Description	Target	Model	Var.	Value	Description	
Ratio Income College/School Share of College Educated Ratio Income Entr./Worker Share of Low-Skilled Entrepreneurs Share of High-skilled Entrepreneurs Ratio Income White/Black	1.9 4.8% 1.5 3.1% 1.5% 5.1	1.9 3.3% 1.9 7.2% 3.2% 6.0	$\eta \\ P_c \\ A_e \\ \sigma_{\varepsilon} \\ \frac{h}{h^{NT}}$	1.035 0.69 2.01 0.32 1.42 0.61	Return to College Price of College Entrep. productivity Variance of a Talent Returns to Skill School quality diff.	
					1 2	

Table 5: Parameters Calibrated Jointly Matching Moments

Notes: Statistics computed for household heads using 1991 South Africa Census data.

Location Choices The main forces in the model that affect residence choice are the quality and availability of education, which are set exogenously, as well as differential endogenous difference in housing prices and income opportunities. Importantly, labor opportunities in equilibrium might differ not only by income – wages and profit for entrepreneurs, but also by availability of some job. For example, high-skilled jobs only would be available in a location where modern technology entrepreneurs open their business. As a result, in the post-Apartheid steady state where all restrictions are lifted, sorting across locations is driven by household wealth and human capital.

Specifically, wealthier households or households with more educated parents are less likely to reside in Townships as depicted in Figure 5. Conditional on level of education and wealth, households with less talented parents are more likely to live in Townships as the returns for kid's education is lower. For wealthy households the probability of living in a Township increases with the level of the kid's talent. However, for poorer household the relationship between kid's talent and residential choice is non-linear, i.e., the probability of living in a Township increases for families with very talented children. The reason behind such relationship is a trade off between higher income of a household today and returns to better schooling and kid's income in the future. For very talented kids in a low-income families the latter one is lower. To summarize, the model rationalizes residential choice of households through the differential access to income sources and educational opportunities relative to a uniform cost of commuting to or living in the city.

While work location for most households is the same as the location of the residence, we observe residential sorting based on the income opportunities determined by household's wealth (i.e. access to working capital) and productivity level. As a result we observe that average income is higher for those living in the City. The model predicts the higher share of traditional entrepreneurs to operate in Township due to high reliance on low-skilled labor, which mostly resides in Townships. In other words, they utilize the opportunity to earn higher profit by paying lower wages to Townships residents. On contrary, entrepreneurs operating modern technology primarily operate their business in the City where most of the high-skilled labor reside.



Figure 5: Location Choices Based on Education and Wealth

(b) Location Choice Based on Wealth

(a) Location Choice Based on Parent's Education

Notes: Both plots depict average probability across residual households' state variables by parent's education (a) and wealth (b). The full distribution across the entire state space is shown in Figure A15

Occupational Choices Occupational choices are mostly determined by the parent's human capital and productivity, as well as their wealth as shown in Figure A16a. Parents with no college degree mostly decide to be low-skilled workers. Only those with high productivity choosing to become traditional entrepreneurs. Those with college degree, predominantly become high-skilled workers. However, the most productive prefer to operate their own business using modern technology. Given incomplete financial markets household's wealth prevents some households realizing their entrepreneurial talent or operate appropriate technology. Additionally, we observe that occupational choice does not depend on the residence as households can choose any work location post-Apartheid.

Educational Choices Rich parents always send their kids to a school in the city as depicted in the Figure A17. More talented kids are more likely to go to college as returns are higher for them. Also, as returns to college depend on a level of human capital obtained in school, parents who can afford to send their kids to college never choose Township school in equilibrium. Importantly, households send their children only to school in Township when their financial assets are not very high. Moreover, presence of borrowing constraint generates in some cases a trade off between physical and human capital preventing some parents to realize their full entrepreneurial potential for a better education opportunities for their kids.⁴⁸ Mestieri et al. (2017) provide household-level evidence consistent with these patterns. Overall, we observe the same patterns in the data, that education of the kids depends on the income, wealth and residence of their parents.

⁴⁸For example, the difference in schooling choice observed in households with the same kids in terms of their talent, as well as the education of parents, but different occupational choices – worker vs entrepreneur.

Savings Decision Savings behavior depicted in Figure A18 is very heterogeneous in the population and is explained by the occupational and educational choices of households. The intertemporal considerations result in smaller savings when kids are more talented, suggesting less need for a bequest when anticipated income of the offspring is high. Additionally, some households prefer bequest over investment in education given the level of human capital of a kid.

4.3 Post-Apartheid Transition: Model and Data

In this section, we compute the transition between the Apartheid and the race-blind steady states. We proceed by lifting off all Apartheid's race-based discrimination policies discussed in Section 4.1, starting with an economy endowed with a distribution of assets and education that corresponds to the Apartheid steady state.

4.3.1 Main Outcomes Along the Transition Path to a New Steady State

The model predicts a relatively slow transition to a new steady state that features convergence of income of Blacks towards average level of Whites along this transition. The typical path for this convergence involves slow accumulation of wealth by Black households, first, by starting as traditional entrepreneurs, and then with higher income and wealth by providing better education to their children or modernizing their business. Ability to make residential and schooling choice speeds up the transition. However, presence of financial frictions in an environment where most Blacks start with very low level of financial wealth, prevents many households from realizing their full potential at the early stages of development. These racial differences in access to college and slow process of wealth accumulation along the transition also imply a substantial delay in access to modern entrepreneurship for Blacks, which for a long time remains essentially White. Therefore, we observe a staggered entrance of Blacks into "opportunity".

As a result of slow process of convergence to opportunity, we observe an increase in income inequality primarily driven by the rising inequality within Blacks. The evolution of income inequality, estimated with the model and measured by the Theil index, is similar to the one observed in the data and depicted in the Figure 6. Initially, all Blacks are equally poor, and therefore their inequality is low. As they start accumulating assets and obtaining access to education, inequality increases. This reflects access to opportunity for (*some*) Black households. In the first periods post-Apartheid, since savings are very low for all Blacks, talent draws play the most important role for occupational choices, asset accumulation, and ultimately inequality. In the following periods, Blacks that got lucky in the first period, continue benefiting from all opportunities while "unlucky" ones are now more limited that before as hosing in the City becomes more expensive due to higher demand. At the same time, most Whites are quite wealthy at the beginning of transition and, therefore, are not much affected by higher housing prices. As a result, the inequality within Black population increases, while remains quite stable within Whites. Once the transition converges to a



Figure 6: Within and Across Race Income Inequality Along Transition Path

new race-blind steady state, difference in income across races vanishes as everyone has access to the same opportunities. However, difference in wealth remains even in the new steady state with Whites being on average wealthier than Blacks.

Figure 7 depicts the location choices by race over the transition path. Time 0 corresponds to the Apartheid steady state, and by construction, all Whites reside in the City and all Blacks reside in Townships. At time 1, we observe a sharp drop in the number of Whites in the City, and over the next periods these process continues slowly until reaching stationary distribution which corresponds to around 30% of living in a City.

The reason for this sharp change in residence location at time 1 is a result of the price difference in housing between Township (zero) and the City. Black households that are very talented move to the City to take advantage of higher wages and better educational opportunities. Likewise, relatively unproductive or low-wealth White households may prefer to re-locate to the Township to save the cost of living in the city (despite the worst schooling opportunities and potentially having to incur a transportation cost). Over the time income and wealth gap between Township and the City is shrinking. Racial mixing across locations and, particularly, in Townships, is clearly not borne by the data: we have not observed Whites moving to Townships. Moreover, not only we observe more residential mixing compared to the data, we also observe more relocation of businesses from the City to a Township driven by higher profit opportunities. Therefore, to account for this facts additional, potentially non-economic, mechanisms will be explored in the next Section.





4.3.2 Model Prediction and Data

So far, our analysis of the transition has focused on the qualitative patterns of the transition dynamics. In this part, we compare the quantitative prediction of our model for the first period of transition dynamics with the respective inequality moments observed in the data. We do that to establish whether current inequality dynamics along all the dimensions documented in the stylized facts can be explained by modeled economic forces.

Income and Race The model predicts decline in income gap across racial groups as in the data, although it does so slightly at a slower rate. Importantly, the model generates declining inequality between racial groups, an increase within Blacks and some decline within Whites. Also, similarly to the data, model predicts more persistent gap between races in terms of the wealth.

Spatial Sorting and Inequality While substantial income gap between Township and the City persists, the level is below the one observed in the data. The main reason for such difference, as was discussed above, is faster mixing of two races in Townships. If instead we look at the income gap between Blacks and Whites residing in the City, similarly to the data, model predicts more racial income convergence compared to overall population.

Inequality and Education and Occupational Choices Model does a good job predicting substantial income gap between those with college degree and those without, both for Black and White households. Similarly, the model generates substantial return to entrepreneurship, particularly for Whites similarly to the data, driven by higher initial human capital of Whites and higher level of assets.

4.3.3 Other potential mechanism not explained by the data (WIP)

As we show in the previous section, while the model does a good job in explaining overall inequality dynamics in South Africa, some of the moments it is not able to replicate. Specifically, model predicts more residential and business sorting compared to the data. For example, one of the striking empirical fact that we document – most of the jobs are still in the City core. This result is in the contrast to model prediction, as it is profitable for some business to move to Township to take advantage of a large supply of relatively cheap low-skilled labor force. To incorporate this into the model, we impose a wedge on the businesses that operate in Townships. While the nature of this wedge can be purely economic, i.e. lack of infrastructure in Townships, it could also capture some social aspects given the history of South Africa. In this paper we do not take a stance on the nature of this wedge and leave it for the future research.

We assume that entrepreneurs face a wedge imposed on their profit, so that their income is a fraction of their actual profit from running a business in a Township, but not in the City, so that

$$\tilde{\pi}^T = (1 - \tau)\pi^T$$

4.4 Model Validation – Distance to the City (WIP)

To validate the model, we compare the transition path of different Townships in the data and in the model. In our analysis we exploit exogenous variation in the distance from a Townships to the closest Metropolitan area. While selection into Township versus City today is endogenous, we argue that the residential choice across Townships is primarily driven by the historical allocation during Apartheid, which was solely based on race and ethnolinguistic characteristics.⁴⁹

For the empirical outcomes we use data from the 1996 and 2011 Censuses, aggregating data at the Township level (note that since this is Census data, we are using data for the entire South Africa and not only Cape Town). As a result, each City – Township pair is an observation. We look at the growth in the average income and change in the share of individuals with completed secondary and tertiary education between 1996 and 2011. Table 6 presents the results of the analysis. To ease our analysis and comparability to the model exercise, we divide all City – Township pairs according to whether they are above or below the median distance to the city. We find that Townships located further away from the city center (above median) exhibit slower income growth, as well as less educational improvement on average. The estimated coefficient remains significant and of a similar magnitude in case we introduce city FE (columns 2 and 4) and therefore we only use within city variation. If we use a continuous measure for distance, we find similar results in magnitude and significance.

⁴⁹As shown in Figure 1, spatial sorting occurred as a result of Apartheid policies, while periods before and at the beginning of Apartheid were characterized by heterogeneous geographic allocation of population in terms of race. Christopher (1990) shows similar patterns for urban areas by computing indices of segregation using Census data from 1911 to 1985. We also perform a set of checks and additional exercises to test for the migration across Townships. For example, by comparing place of birth and residence using Census data. The results suggests that migration across Townships is limited, and most of the migration flows are from a Township to a City.

	Edı	ucation	HH Inc	HH Income		
	(1)	(2)	(3)	(4)		
Distance to City	-2.722 (1.047)	-2.109 (0.931)	-0.131 (0.052)	-0.124 (0.066)		
City FE		\checkmark		\checkmark		
Observations	148	148	148	148		

Table 6: Township Outcomes: 1996 vs 2011 Difference

Notes: Columns (1), (2) use the change in share of individuals with completed secondary and higher education. Columns (3), (4) use the change in average HH income and control for change in average education level. All columns include dominant language as control. Distance to city is a dummy for Townships with higher than median distance to the city. The results are similar if absolute distance is used. St. errors (in parenthesis) are clustered at MN level.

We next turn to our quantified model and perform an analogous exercise to the empirical analysis. We do so by computing the transition dynamics under different values for the transportation costs—which proxy for the effective distance between City and Township. More concretely, we varying τ in a manner similar to the data. We compute two counterfactual transitions between the Apartheid and the race-blind equilibrium: one with low transportation costs (10.3% of the low-skill salary) and one with a high transportation cost (50% of the low-skill salary). We find that the transition is slower with higher transportation costs, including slower racial mixing. Consistent with the empirical findings, the model predicts that Townships located closer to the city are characterized by richer on average households in terms of assets and income, higher level of human capital and more individuals with college degree, and also higher levels of entrepreneurship.

Policy Lessons for Infrastructure Improvements The counterfactual analysis performed to validate the model sheds light on the importance of transportation infrastructure in shaping the transition of the economy out of the complete segregation created by Apartheid. Indeed, relocating Townships may be prohibitively costly, but the relevant dimension for agents is the economic cost of commuting. Therefore, infrastructure improvements (be it in the form of improved roads, better transit system, improved safety, etc.) that reduce the cost of moving from Townships to cities can affect the speed of the transition. In particular, we see that reducing the commuting costs makes Townships less of a "trap" for Black households, and allows them to have an easier access to opportunities in the city. We leave for future work using our framework to quantify the potential gains of such infrastructure improvements.

5 Conclusion

We study the evolution of racial inequality in post-Apartheid South Africa, focusing on the role of urban areas and the persistent effect of Apartheid-era Townships on present-day inequality. We use historical

data pre-, during, and post-Apartheid to establish some stylized facts about the evolution of inequality in South Africa across time and space. We show that spatially segregated cities became a salient feature of the South African geography during Apartheid and still shape the economic development of the country. We then investigate various factors, such as educational, occupational and residential choices, in the observed persistence of inequality. These facts guide our subsequent modeling choices and are used to inform our quantitative exercise.

Motivated by this evidence, we develop and quantify a rich model that features spatially segregated residential, educational, and labor markets. We study the evolution of inequality and access to opportunity for Blacks within our calibrated model. Our model is able to capture salient facts of the Apartheid and democratic eras in South Africa. It implies a protracted entry of Blacks into college first, and then into modern entrepreneurship. As a result, model predicts consistently with the data rise in inequality driven by the substantial increase of income gap within Black population. We also find that spatial segregation plays a substantial role in slowing down the convergence between Blacks and Whites, and that reducing commuting costs can be a powerful lever to speed up access to opportunity.

Our framework can be used to assess the impact of alternative policies to give access to opportunity. Importantly, our framework can account for general equilibrium and long-run effects that can complement the information given by micro studies. In addition to assessing the importance of infrastructure improvement, our framework can be used for other policy analysis. For example, to assess the long-run and general equilibrium impact of public housing efforts through the Reconstruction and Development Programme (RDP) and thus complement the analysis of Picarelli (2019).

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Online Appendix

A Additional Tables and Figures

A.1 Data and Stylized Facts





Source: Smith (1992)

Notes: Ten Homelands and their respective ethnicity: Transkei and Ciskei (Xhosa ethnicity), KwaZulu (Zulu), Bo-phuthatswana (Tswana), Venda (Venda), Gazankulu (Tsonga), Lebowa (Northern Sotho), QwaQwa (Southern Sotho), KaNgwane (Swazi), and KwaNdebele (Ndebele). Four Bantustans became independent: Transkei in 1976, Bo-phuthatswana in 1977, Venda in 1979, and the Ciskei in 1981,



Figure A2: Typical Model of the Apartheid City of South Africa

Source: Smith (1992)

Notes: 'Black Townships' are located near the industrial areas; buffer strips are arranged between ethnic groups. Squatters were not allowed in the city, but could be tolerated in a Bantustan area outside the city boundary.

	Live	in City	Live in Township	
	school	college	school	college
Commute to City	89.9%	97.1%	18.2%	85.1%
Commute to Township	10.1%	2.9%	81.8%	14.9%

Table A1: Share of Individuals by Location of Home and Education Place

Notes: In the data we also observe whether individual is a scholar, which represents those going to school, or attains the tertiary institution, which represent those going to college. We use broad definition of Townships. Using narrow definition of Townships results in even stronger pattern observed in the Table.



Figure A3: Historical Race Distribution Across Districts: Same Districts 1936 & 1980

Notes: Each plot depicts the distribution of the levels of maximum share of one racial group within one district. 100 percent implies fully homogeneous district in terms of racial composition. There are four racial groups used in the analysis: Whites, Blacks, Coloureds, and Indians. Sample is restricted to the same geographical definition of individual districts

	College Degree	Average Wealth	Average Income
$\tau = 0.103 wld$	0.97	0.70	0.80
$\tau = 0.3 wld$	0.76	0.95	0.95
$\tau = 0.5 wld$	0.57	1.01	0.91

Table A2: Outcomes of Township Relative to the City

Notes: College ratio reflects absolute number of people going to college in each location, while for income and wealth it's the average for each location.

A.2 Model

B Historic Background: Apartheid in South Africa

In this section we provide more details on historical context on different aspects of racial segregation in South Africa.

B.1 South Africa Before Apartheid

Land dispossession in South Africa started in 1652, when the Dutch East Asian Company established the Cape Colony. One of the first things that was done after the arrival of the Dutch, was to drive out the local Khoi cattle from their grazing land below Table Mountain. Only those Khoi who were prepared to work for the Company were allowed to remain on their lands. During the 18th and 19th centuries more African chiefdoms lost most of their land to the white settlers. And by the late 19th century, whites obtained control over most of South Africa. The land was divided between the two Boer republics of the Transvaal and the

Figure A4: Distribution of Population Group Shares Across Enumeration Areas (1991)



Notes: Each plots represent the distribution of shares of a given population group based on HH Head across EAs in Metropolitan districts in 1991 Census into 20 equal bins. Distributions for Coloureds and Indians looks similar. Shares are computed only for the main part of the Census, as share of Blacks in Bantustans is more than 99.0% in the data.

Orange Free State, and the two British colonies of the Cape and Natal. The mineral discoveries in the late 19th century led to the outbreak of the Anglo-Boer War in 1899 over the control of resources. And then in May 1910, the Union of South Africa became an independent dominion within the British Empire after the South Africa Act been passed in September 1909.

The first government of the Union in 1910, the South African Party of Generals Botha and Smuts, represented mostly interests of mining and industrial groups. In 1913, the Natives Land Act was passed, which made the reserves the only areas where Africans could lawfully acquire land. Later in 1919 Hertzog founded the National Party, which took the power after the national elections in 1929. For the first time the issue of color was widely used as a campaign tool, and Hertzog represented effectively White South Africa. However, as a result of economic upheaval caused by the Great Depression, Hertzog's government (which is considered by many Afrikaners as too mild in its approaches to segregation) made a coalition with Jan Smuts and formed the United Party by merging two existing parties, National and South African, in 1934. The same year Daniel Malan formed a Purified National Party that had much stronger views on racial segregation. The outbreak of World War II led to some disagreement between Hertzog and Smuts, and in 1939 Hertzog resigned. While in 1943 general election brought Smuts to power, a lot of seats were won by the Nationalist Party of Daniel Malan. On May 26th, 1948 the National Party won a narrow majority in the house of assembly in alliance with a small Afrikaner Party. The era of strict apartheid began. This period was characterized by an oppressive system of laws and regulations that kept Blacks, and to the smaller extent Coloureds and Indians inferior to Whites by institutionalizing and reinforcing the already existing



Figure A5: Map of South Africa (1991 Census)

Notes: Bantustans are colored in red, and metropolitan areas - in dark blue.



Figure A6: Share of Non-White Population

Notes: based on data from 1996 and 2011 Census for 8 Metropolitan Municipalities. Numbers reflect average shares across Township and non-Townships SALs/EAs. Broad definition of Townships is used. The patterns are almost identical if the total share in respective group is computed.

Figure A7: Map of Khayelitsha Township (2011 Census)



Notes: based on geographical data from Statistics South Africa for Small Area Locations in 2011 Census, and Townships locations. Light blue areas corresponds to non-populated areas, rather than reflect discrepancies.

segregation policy.

B.2 Forced Internal Resettlement

Broadly, people have been moved from White rural areas, from the urban areas and within the Homelands. In addition, people have been moved in order to clear the land for dams, game reserves and agricultural development, as well as to clear the border of South Africa. The process of forced removals is described in more details below.

The Land Act (1913) and the Native Land and Trust Act (1936) consolidated areas settled by White farmers and demarcated reserves for the Black population. As a result of these acts, only slightly more than 10 percent of land was assigned to Blacks who comprised more than 70 percent of population. In addition, increased level of mechanization in agriculture in the middle of twentieth century led to a smaller labor demand. Moreover, the demand shifted towards more skilled workforce to operate the machines. Combination of these factors led to overcrowding and poverty in rural areas resulting in increase in urban population in 1950s by 50 percent (Abel, 2019). As a result of rapid urbanization and increasing opposition to racist policies, the apartheid government passed legislation that formed the legal basis for forceful internal resettlement of non-Whites.

First, the system categorized all population of South Africa into racial groups, and then further categorized all Blacks along narrower ethnic lines. Specifically, Population Registration Act of 1950 codified the population into three groups: White, Coloured, and Native (Indians were added later), while every Coloured and Native person was classified further according to their ethnic or other group to which they belonged. Figure A8: Real Income Dynamics across Racial Groups



Notes: The plot depicts the average annual real income of a given group of individuals. The price index is normalized to 1 for year 1991. Data is restricted to eight Metropolitan areas. The sample is restricted to employed household heads of working age (25-50).

Second, the Group Areas Act of 1950 and Prevention of Illegal Squatting Act of 1951 created ethnically homogenous Townships outside the cities and forcefully removed people from informal settlements according to their racial classification. It was compulsory for people to live in the area that was designated for their group. In addition, Black (Urban Areas) Consolidation Act of 1945 consolidated the laws relating to the control of Africans in urban areas and their residence in those areas. Jointly with the Black Labor Act of 1964 and the Black Labor Regulation, they became a core of the influx control system in urban areas of South Africa. Importantly, Section 10(1) of the Black Consolidation Act specified the categories of Africans that were allowed to remain for longer than 72 hours in a prescribed urban area. Specifically, the person must:

- a) have been born there and lived there continuously since birth
- b) have worked there continuously for one employer for 10 years or worked there continuously and lawfully for 15 years
- c) be the wife, unmarried daughter or son under 18 years of age of Africans falling either a) or b) above
- d) have been granted a permit to live there by a labor bureau.

Blacks without Section 10 rights stayed in urban areas under the risk of arrest, conviction and deportation.

Finally, the Bantu Authorities Act of (1951) and Bantu Resettlement Act (1954) created ten separated ethnic Homelands, Bantustans, that became destination of large scale removals of people. These Homelands were considered as independent states, and the government assigned each African to a particular Homeland according to their origin. Specifically, ten Homelands and respective ethnicity were: Transkei



Figure A9: Within and Across Race Income Inequality Evolution

Notes: Inequality is measured by Theil index, which is further decomposed into the part that is due to inequality between Blacks and Whites and within two races. Data is restricted to eight Metropolitan areas.

and Ciskei (Xhosa ethnicity), KwaZulu (Zulu), Bophuthatswana (Tswana), Venda (Venda), Gazankulu (Tsonga), Lebowa (Northern Sotho), QwaQwa (Southern Sotho), KaNgwane (Swazi), and KwaNdebele (Ndebele). The shape of Homeland territory were rather determined by the interest of White farmers and the location of mineral deposits than by historic tribal areas as was claimed by the apartheid government (Desmond, 1971).

In 1970, all Black population became citizens of one of the ten Bantustans. The government hoped that all ten Bantustans would opt for "independence," which would have ensured that African people who cannot be removed physically would have became citizens of a foreign state. When Transkei became independent in 1976, Bophuthatswana in 1977, Venda in 1979, and the Ciskei in 1981, all Xhosa, Tswana and Venda-speaking South Africans became foreigners in South Africa. In terms of the residence in urban areas, those Black people who were citizens of independent Bantustans but who had Section 10 rights to be in town in White South Africa retained these rights after independence. However, the children who were born after the date of independence of the parents Bantustan had no such right. In 1985, citizens of independent Homelands could reapply for South African citizenship, and Bantustans were reincorporated into the Republic of South Africa after the 1994 elections.

Categories of Removals The largest category of removals was the relocation from white farms, including the clearance of all the smaller African residential areas, known as "Black spots," within White areas, and the consolidation of African population in Bantustans. Normally, people moved off White-owned farms became tenants or workers on the farms owned by White person. But often, poor conditions on the farms and low wages forced them to leave. For many of ex-farm workers moved to the Bantustans, the only way into the labor market was to become a migrant labor.



Figure A10: Income Dynamics across Racial Groups in 2011

Notes: Each plot represents the average annual nominal income of a given group of individuals. Markers for income by education and employment reflect the size of a given category within respective racial group. Data is restricted to eight Metropolitan areas. The sample is restricted to employed household heads of working age (25-50).

To keep Blacks out of urban areas a large set of laws operated. Group areas removals was the largest category of relocation in urban areas into segregated urban Townships. This segregation was accompanied by the system of strict influx control aimed at reducing the number of Africans living permanently in urban areas. In 1960s there was massive relocation as a result of deproclamation of existing Townships. In case the town was within 75 kilometers of Bantustan, the Black Township was deproclaimed and people were moved to a new rural Township in Bantustan. As a result, workers became commuters if they live close enough to the city, or migrants if too far. Sometimes, Townships have been incorporated into the nearest Bantustans or the borders were redefined to include Townships. This meant that people lived in those Townships lost their right to live and work in urban areas. The only type of informal settlements that were allowed to remain are those located on Bantustan territory. But even there, people leaving in large informal settlements outside rural Townships faced potential relocation if Bantustan authority decided to expand the Township or clear the shacks when it was hard to control their inhabitants.

Different periods are characterized by relocation of different groups of people. In the 50's and 60's mostly affected by removal policies were victims of the Group Areas Act, planning in Bantustans, and elimination of black spots and labor tenancy in White rural areas. On a large scale removal of whole Townships as a part of urban relocation only began in the late 60's. The consolidation of Bantustans became large only in the mid 70's.



Figure A11: Cape Town in 1990s vs 2011

Notes: the upper figure shows the map of Cape Town under Group Areas Act during Apartheid period. The lower figured is constructed using 2011 Census data by Adrian Frith, https://adrian.frith.dev/dot-maps/





Notes: Each plot represents the average annual nominal income of a given group of individuals. Data is restricted to eight Metropolitan areas. We use broad definition of Townships.

Legal Basis of Relocation The major laws that provided the legal basis of black land rights and relocation include:

The Black Land Act, No. 27. 1913 Prohibited blacks from owning or renting land outside designated reserves, which constituted 7.6% of the total land area of South Africa. The size of property inside the reserves is also limited. This led to the majority of Africans not being able to live as subsistence farmers and were forced to work for wages on white farms or industry.

The Black Administration Act, No. 38. 1927 Set up a separate legal system for the administration of African law and made the proclaimed Black areas subject to a separate political regime from the remainder of the country, which required municipalities to accept responsibility(including financial) for the provision of permanent urban settlements. In addition, it included the clause which allowed to move any person from one place to another one when it was in "general public interest."

The Slums Act, 1934 Enforced the demolition of slums and expropriations to enhance segregation.

The Development Trust and Land Act, No. 18. 1936, as amended Expanded the area of reserves to 13.6% of the total land in South Africa. Authorized the elimination of "black spots" (i.e. black-owned land surrounded by white-owned land).

The Black (Urban Areas) Consolidation Act, No. 25. 1945, as amended Structured influx control of black males. Was amended in 1952 to specify that all black people have to carry passes and are not allowed



Figure A13: Share of Population by Highest Level of Education

Notes: Numbers reflect the share of individuals by the highest level of education obtained for 8 Metropolitan Municipalities. Broad definition of Townships is used. For White population the share of those who never went to school is 0.3% and 0.25% for 1991 and 2011, and for Black population the respective shares are 9.0% and 3.1%.

to stay in the urban areas longer than 72 hours unless they permission governed by Section 10.

The Group Areas Act, No. 41. 1950, as amended Physically and spatially separated White, Black, Coloured and Indian people by declaring areas for exclusive use of one particular group. It became compulsory for people to live in an area designated for their group.

The Prevention of Illegal Squatting Act, No. 52. 1951, as amended Prohibited persons from entering or remaining in a land/building without owner's permission. It gave power to remove squatters from urban areas to any determined place and demolish their dwellings.

The Blacks (Abolition of Passes and Coordination of Documents) Act, No. 67. 1952 Repealed the laws related to the carrying of passes by blacks, and led to the issuance of reference books to all blacks in all provinces.

The Blacks Resettlement Act, No. 19. 1954 Established a Resettlement Board responsible for removals of blacks from Townships.

The Promotion of Black Self-Government Act, No. 46. 1959 Transformed reserves into independent Bantustans, dividing blacks into ethnically discrete groups. In addition, abolished parliamentary representation of blacks.

The National States Citizenship Act, No. 26. 1970 as amended Required all black people to become citizens of a self-governing territorial authority. Act forced black people to be citizens of Homeland of their residence and denied South African nationality, the right to work in South Africa, etc.

The National States Constitution Act, No. 21. 1971 as amended Provided for the granting of increased powers to Homeland governments, hence, facilitated their eventual independence.

The Slums Clearance Act, No. 76. 1979



Figure A14: Income Dynamics across Racial Groups in 1991

Notes: Each plot represents the average annual nominal income of a given group of individuals. Markers for income by education and employment reflect the size of a given category within respective racial group. Data is restricted to eight Metropolitan areas. The sample is restricted to employed household heads of working age (25-50).



Figure A15: Probability of Living in a Township

Notes: On the y-axis white dashed lines separate different values for parents talent, while kid's talent varies within each cell (between dashed lines) and distribution is fixed across cells. Similarly for x-axes, parent education varies between cells and level of assets within the cells. For education, ST stands for school in Township and no college, CT – school in Township and college, SC – school in non-Township and no college, CC – school in non-Township and college.

Abolition of Influx Control Act, No. 68. 1986 Amended the 1927 Black Administration Act in order to repeal sections relating to the removal of black communities as well as black individuals.



Figure A16: Parent Occupational Choice

Notes: On the y-axis white dashed lines separate different values for parents talent, while kid's talent varies within each cell (between dashed lines) and distribution is fixed across cells. Similarly for x-axes, parent education varies between cells and level of assets within the cells. For education, ST stands for school in Township and no college, CT – school in Township and college, SC – school in non-Township and no college, CC – school in non-Township and college. Educational and Occupational choices for those residing in Non-Township is depicted in Figure **??**.

Identification Act, No. 72. 1986 Repealed the 1952 Blacks (Abolition of Passes and Coordination of Documents) Act and large portions of the 1950 Population Registration Act. Race group would be no longer reflected in a person's identity number.

Restoration of South African Citizenship, No. 73. 1986 Granted South African citizenship to TBVC citizens, i.e. citizens of independent Bantustans, who were born in South Africa prior to their Homeland's independence or who resided in South Africa permanently.

While the above list is not comprehensive, we believe, that it includes the most important laws that directly affected the process of relocation. In fact, there were a number of local and innocuous laws not directly related to relocation, but that may have been used to remove people as well. For example, laws that regulated town planning and zoning.

The role of Township in the process of resettlement Most Townships that exist today were developed during the period between 1948 and 1960, that was characterized by the extensive development of Townships to accommodate removals from White areas.

As described in Lester et al. (2009), Townships were developed during Apartheid period using the following approaches:

- Adequate distance from the white town and surrounded/separated by buffer areas (e.g. railroad, industrial area);
- There should exist land to expand away from white areas;
- Should adjoin an existing African Township to minimize total number of areas for Africans;

Figure A17: Educational Choices for Kid



Notes: On the y-axis white dashed lines separate different values for parents talent, while kid's talent varies within each cell (between dashed lines) and distribution is fixed across cells. Similarly for x-axes, parent education varies between cells and level of assets within the cells. For education, ST stands for school in Township and no college, CT – school in Township and college, SC – school in non-Township and no college, CC – school in non-Township and college.

- Should be within reasonable distance from the town, as well as from the main and national roads, for transport purpose with one road connecting to the town (rail preferred);
- Housing should be built (minimum amenities and quality standards) and allocated in areas that are formed based on different ethnic groupings.

Table B3 provides detailed timeline of Township development during 20th century.

B.3 Access to Labor Markets, Education and Financial Services during Apartheid

Labor Markets Under the Nationalist this system became a sophisticated method of labor allocation and control. To keep political power and wealth in White hands, the government needed to control the flow and location of black labor and it adopted a policy of restricted urbanization. And one of the consequences of the policy of restricted African urbanization was the strengthening of the migrant labor system after 1948.

First, in the 1960s and the 1970s people that were moved into Homelands were forced into migrant labor. Second, the government favored commuting over migrant labor by providing generous incentives to industrialists to set up their business on the border of Bantustans.⁵⁰ Finally, a network of labor bureaus was established to control the number of people allowed to enter urban areas and to direct labor to the areas/sectors in need. At the beginning only rural work seekers had to go through the bureaus, which

⁵⁰As defined in Desmond (1971), *Border industries* are white-owned, state-aided industry located near a Homeland, intended to decentralize industry, to reduce the migration of African workers into established White cities and to provide work for the Homelands.





Notes: On the y-axis white dashed lines separate different values for parents talent, while kid's talent varies within each cell (between dashed lines) and distribution is fixed across cells. Similarly for x-axes, parent education varies between cells and level of assets within the cells. For education, ST stands for school in Township and no college, CT – school in Township and college, SC – school in non-Township and no college, CC – school in non-Township and college.

were located in the towns. In 1964 bureaus became in charge of employment of all Black workers in the urban areas, including permanent residents. In 1968 labor bureaus were set up in the Bantustans.

As noted in Platzky et al. (1985), the further people were relocated from metropolitan and White urban areas, the less employment opportunities they had. The following example provided in Platzky et al. (1985) gives a clear illustration of the above statement:

"...Border Townships are relatively favoured. They have been created to supply labor to industries and towns within commuting distance,... . Often, however, the commuting distance can be up to 60, 70, or even more kilometers each way, and workers spend most of their 'free' time travelling between work. and home in overcrowded, slow buses.

An extreme example is the little town of Alicedale, in the Eastern Cape. About 700 people forced to move from Riebeeck East (only 48 kilometers from their work) to Alicedale in 1981. There was absolutely no local work in Alicedale. Some men, however, managed to get jobs in the South African Railways goods yard at Port Elizabeth. They start work at 7 a.m. and finish at 4 p.m. Their actual day, however, is far, far longer. In order to be at work on time, the men wake at 2 a.m. each day, wash and dress, and then walk for 20 minutes in the dark to catch the 3 a.m. train at Alicedale station. After work they catch the train back home again, getting back to the station at about 9 p.m. They then have to walk home, eat, and go to sleep in time to start once more the next morning at 2 a.m."

Moreover, some jobs and occupation were reserved for specific racial groups. For example, **Black Building Workers Act, No. 27. 1951** prohibited blacks from performing skilled work in the building industry in white urban areas.



Figure A19: Educational and Occupational Choices of Households Residing in Townships

(high commute costs)

Notes: On the y-axis white dashed lines separate different values for parents talent, while kid's talent varies within each cell (between dashed lines) and distribution is fixed across cells. Similarly for x-axes, parent education varies between cells and level of assets within the cells. For education, ST stands for school in Township and no college, CT – school in Township and college, SC – school in non-Township and no college, CC – school in non-Township and college.

Education The Bantu Education Act (1953) introduced a separate education system for black learners, and in 1959 separate universities were created for black, coloured and Indian population with existing universities not being allowed to enroll additional black students. Desmond (1971) describes the main elements of Bantu Education system development since 1953. First, English language was forbidden as a medium of instruction, and each school must have been using the tribal language. Second, the common curriculum with White schools used before was abandoned. Specifically, in most schools, history, geography and most of the science were no longer taught. Instead, schools were focused on manual work, gardening and housework. Third, while enrollment in primary school was pretty high, only about 4 percent of total attended secondary school. For example, out of more than 2.5 million children at school only 869 matriculated in 1969 (Desmond, 1971). Finally, the tribal colleges, which replaced Black places at South African universities, focused on occupational needs of Homelands, i.e. diplomas in commerce, teaching Bantu languages and improved husbandry. In terms of the expenditure on education, there was a huge gap in expenditure on White and Black learners. In 1953, the cost of education per capita for Whites was £50, which increased to £70 ten years later, and the respective numbers for Blacks were £9 and drop to £6. At the same time, the ratio of state-paid teachers for African learners changed from 1:42 in 1949 to 1:72 in 1968. Fedderke et al. (2000) provides systematic overview of difference in educational resources across different racial groups during 20th century.

Although the Bantu Education Act was replaced by the Education and Training Act in 1970, fundamental inequalities remained. Among the legislation that led to segregational education policy during apartheid, there is **Black Education Act, No. 47. 1953** formalized segregation of black education and provided a foundation for Bantu Education. **Extension of University Education Act, No. 45. 1959** empowered the Minister of Bantu Education to designate colleges for specified African ethnic group. Black students were not allowed to attend the University of Cape Town or the University of Witwatersrand without permit.

B.4 Democratic South Africa during Post-apartheid period

C Data

Township Data As a "broad" definition of a Township, we rely on the data from the South Africa Township Opportunity Atlas provided by AfricaScope. They define Townships as formal or informal urban residential areas where there is a predominance of previously disadvantaged people. In other words, residential areas where more than 80 percent of residents classify themselves as either Black, Coloured, or Indian. To generate the boundaries of Townships, they use a combination of variables, such as the EA GeoType, EA type and Main Place data, from the 1996, 2001, and 2011 Censuses to identify all enumerator areas that are racially exclusive in the period when survey conducted. In order to account for the expansion of existing Townships, AfricaScope uses satellite imagery and the typical homogeneity of settlement pattern and dwelling type in Townships to annually adjust the Township boundaries. Moreover, only areas that satisfy the above criteria and located in urban areas (i.e. rural areas were excluded) are classified as Townships. Similar definition of Townships is used in Lester et al. (2009), except that they exclude Townships that are located in former Bantustans.

A Township correspondence was created between the South African 1996, 2001 and 2011 Census Enumeration Areas (EAs) or Small Areas (SALs) and AfricaScope's Township boundaries map. We use geospatial datasets provided by Statistics South Africa for all Census localities. These geospatial data files contained the Enumeration Areas or Small Area for the respective Census years and each EA's or SAL's unique code, province, district, main-place, and sub-place name. The correspondence was thus developed by linking Township names and their location to each EA or SAL based on the EA's or SAL's code, Subplace and Main place name, as well as its geolocation.

Importantly, this broad definition of a Township includes not only Townships formed during the apartheid period but also those formed post-independence and informal settlements. For a "narrow" definition of a Township, we use historical records and manually identify those formed as a result of an apartheid segregation policy. In addition to separating historical and post-Apartheid Townships, we were able to identify Townships that were not included in the AfricaScope list but appeared in historical maps. To do that, we referenced maps in the academic literature discussing the geographic impact of Apartheid. The maps provided in the essays ranged from 1908-1991 and distinguished official Townships from infor-

mal settlements. Each Township identified using this method was cross referenced with archival sources based on small place name to confirm its origin. Given the lack of systematic historical records, we had to limit our search to major Metropolitan areas. To connect the historical and contemporary Townships, we manually related the historical maps to the present demographic maps. For modern Townships beyond the scope of the archival maps, we used the research archive to find the history of each Township using the names provided by AfricaScope. We distinguished legally established Townships from squatter areas and informal settlements using the archive. All of the Townships identified as historical were legally identified by Apartheid laws before 1991 and continue to have at least 80% non-white residents, according to the 2011 Census.

To do that we referenced maps in academic literature discussing the geographic impact of Apartheid, specifically *Homes Apart: South Africa's Segregated Cities, The Black Man's Prtion,* and the UCT historical map collection. *Home Apart* provided the majority of the reference maps of Metropolitan areas for the years 1908-1991. The most consistently detailed maps were made in 1990, a year before the publication of the essays, and distinguished official townships from informal settlements as well as Black, White, Indian, and Coloured living areas. Given the lack of systematic historical records, we had to focus on major metropolitan areas: Buffalo City (East London), City of Cape Town, Ekurhuleni Metropolitan Municipality (East Rand), City of eThekwini (Durban), City of Johannesburgm Mangaung Municipality (Bloemfontein), Nelson Mandela Bay Metropolitan Municipality, and City of Tshwane (Pretoria). Historical Metropolitan names are identified in the parentheses.

After identifying sources of historical Township locations, we manually related the historical maps to a demographic map of the 2011 Census. Once areas were roughly identified on the demographic map, the identified areas were compared with maps of each Metropolitan area with at least 80% non-White population according to the 2011 Census data. Once the demographic criteria for this paper's definition of Township was confirmed, each area's name was checked against the AfricaScope Township list. Names that were not on the AfricaScope list were noted as independently identified historical Township areas.

Household data Our main analysis uses data from Population Censuses conducted around the end of Apartheid period in 1991, and in a more recent period – 2011. We complement our main analysis with the data collected during the 1996 and 2001 Censuses' rounds.

1991 Census Data. For the 1991 Census, we are able to observe all individuals and their socioeconomic characteristics surveyed in South Africa and three independent Homelands – Bophuthatswana, Venda, and Ciskei. Data for Transkei are not available, but since we focus on major Metropolitan areas, this does not compromise our analysis. The total population surveyed during the 1991 Census data collection is 22.6 mln people. To account for the missing part of the population, Statistics South Africa assigns weights that are used throughout this analysis. To obtain geospatial information on the District in the 1991 Census, we use Giraut and Vacchiani-Marcuzzo (2009) database, which harmonizes and interrelates over time the

following and functional maps of the districts, provinces, and urban areas for South African localities from 1911 to 2001. We limit our sample to Metropolitan districts in 1991, excluding the ones that were located in Orange Free State to ensure consistency of Metropolitan locality definition between 1991 and 2011 and focus on the main urban areas only. This results in 53 metropolitan districts linked to seven major cities: Cape Town (11), Durban (10), Port Elizabeth (2), Johannesburg (10), Pretoria (8), East London (4), and East Rand (8). These metropolitan districts account for 41.1% of the population adjusted for the undercount or 35.2% of the surveyed population.

To avoid issues related to household characteristics such size, composition, and presence of domestic workers residing jointly with households and others, in our analysis, we focus only on the head of a household. The racial distribution of these households is the following: Black – 46.5%, White – 36.2%, Coloureds – 11.5%, and Indians – 5.8%. We restrict further our sample to two major groups – Black and White populations. While the lowest level of geographical unit available in 1991 Census is Enumeration Area, we are only able to geolocate districts for this time period. Therefore, we assume that all Black households reside in Townships and all Whites – in the core of the cities. Indeed, the share of different groups across enumeration areas depicted in Figure A4 represents bimodal distribution with most of the mass being either at 0 or 100 percent.

We observe the following household and individual characteristics both for the main Census, as well as for independent Bantustans: age, marital status, place of birth and citizenship, religion, literacy and level of education, occupation and current employment status (employee, employer, or unemployed), sector of employer (public, private, government, etc.) and economic sector, and income. We use these variables to analyze how Black and White households differ in various socioeconomic aspects and inform our quantitative part. To link model and the data, we further restrict our sample to adults age of 25 to 50. This also allows us to look at individuals that lived almost all or all their life throughout the Apartheid period. As a result, our sample consist of 1.6 mln adjusted for undercount Black or White heads of households between age of 25 and 50 residing in one of Metropolitan districts of South Africa or former independent Bantustans.

In terms of other characteristics, 80 percent of the heads are male with 73.4 percent of the total being married or living with their partner. In terms of the education, we classified the highest level of education obtained by each individual into five broad categories: no schooling, some primary, some secondary, finished secondary or matric, and higher education. To do this, we used crosswalk from a set of almost 20 narrow education developed by Statistics South Africa for 2011 Census. As a result, we have that about 10 percent of population having some higher education, 26 percent finished secondary, 57 percent some secondary or primary, and 7 percent have no schooling. Distribution of education level by population groups is depicted in Figure A13. For the employment status we are able to classify individuals into the following groups: employees, employers or self-employed, not economically active, and unemployed looking for work. In the data we treat entrepreneurs as those who has work status in Census as employer or selfemployed, and in addition who states "Private Business" as an employer.⁵¹ Overall, there are about 76 percent of individuals are employed workers, 11 percent are employers or self-employed, and the rest are unemployed either looking or not for a job. Finally, we are able to compare annual income for various groups of population. For Bophuthatswana actual income is reported, while for Ciskey and main Census only brackets. We assign individual income using median value of the bracket.

1996 and 2011 Census Data. The lowest level of data aggregation that is available to researchers and allows to map socioeconomic outcomes to Township variable is Enumeration Area (EA) for 1996 Census and Small Area Location (SAL) for 2011 Census. Those areas on average contains approximately 500 - 600 people. In the analysis we focus on eight Metropolitan Municipalities, which accounted for 32 percent and 40 percent of population in 1996 and 2011, respectively, and mostly urban. To map EAs and SALs to Township variable we use geolocation. In addition, using geographical data, for each EA and SAL we compute the distance to the closest city of population 100,000 people or more, as well as to the largest city in a given Municipality. ⁵² To ensure, that our mapping captures spatial allocation of different ethnic groups during the Apartheid period we compute the share of non-White population in non-Township part of the city and Townships in 1996 (Figure A6). In addition, the numbers computed using data from 2011 Census, point to substantial persistence of segregation over time. First, the share of non-White population remains stubbornly high at almost 100 percent. Second, the share of non-White population in non-Township parts of the cities, while higher compared to 1996, remains well below the total share of this group in those municipalities.

In addition, to compare outcomes obtained for 1991 Census with more recent data, we use individual level data for 10% of the Census data. Given rich set of variables available for each individual, Statistics South Africa doesn't provide sufficient level of geographic aggregation to also map individuals to Township data.

Education data We use data from the education datasets available in South Africa, mostly from the Department of Basic Education (DBE). Education data provide information on number of characteristics, such as number of students and teachers, for the universe of schools in South Africa across number of year in 2000s. In addition, geographical location of schools is available, so we can identify whether school belongs to a Township.⁵³

Commuting data To obtain information on the location and of work and school choices relative to the place of residence, as well as the time and cost of commuting, we use a representative household survey data collected by the City of Cape Town in 2013. Data includes information on more than 22,000 households and 63,000 individuals.

 $^{^{51}\}mbox{We}$ want to exclude those who are self-employed and works for NGO or government.

⁵²The amount of SALs in one Township ranges from 1 to 1442 (Soweto), while the median level is equal 39 in studied Municipalities. An example of mapping of SALs to Township is provided in Figure A7 in the Appendix for Khayelitsha Township in the City of Cape Town Municipality.

⁵³Overview of available education datasets is provided in van Wyk (2017).

For each household and person, a set of socio-economic characteristics is collected. For each household, we observe the following characteristics: size, type of dwelling, number of owned or used cars and motorcycles, number of domestic and garden workers and frequency of their work, monthly household income from all sources, and derived value and asset group. In addition, the survey records the addresses of households' residences at the level of street name, suburb, town, and postal code. We geocode these addresses using the Google Geocoding API and map those addresses to our Township data. As addresses are not recorded in the same format and some missing information is present in the data, we further verify the obtained geolocations by restricting the derived latitudes and longitudes with Cape Town Metropolitan Municipality. This reduces our sample by 2 percent, to 21,835 households.

The dataset contains demographic and travel information on 63,531 individuals who belong to a given household. For each individual, we observe their gender, age, level of education, as well as employment or education status. Importantly, for each individual we observe their daily travel patterns, i.e. where and how they commute, how long it takes them, and how much does the commute cost. For our analysis we restrict our sample to those who commute to work and to the place of education. Similarly to home addresses, we use the Google Geocoding API to geocode and map destinations. Finally, we further verify the obtained geocolocations and limit our sample to those who commute to places of work or study within Cape Town Metropolitan Municipality.⁵⁴ As a result we get 29,586 commuters.

Our final sample of merged household and individual commuters data contains 29,009 individuals from 14,383 households with 67 percent of individuals commuting to work and the rest to the place of education.

This allows us to obtain information on the model moments, such as the share of households that live in Townships and work or send their kids to school in the City, and whether distance and cost affect various socioeconomic outcomes of households.

D Detailed Derivations for the Model Section

Household Utility Function An individual's utility function is described by

$$U = \frac{c^{1-\sigma}}{1-\sigma}$$

with $\sigma \ge 0$. We assume that household utility function is determined by the consumption of a parent, c_p , and consumption of a kid, c_k . Each household solves the following maximization problem:

$$\max_{c_{p,c_{k},a,e_{educ}}} U^{HH} = \lambda \frac{c_{p}^{1-\sigma}}{1-\sigma} + (1-\lambda) \frac{c_{k}^{1-\sigma}}{1-\sigma}$$
(18)

⁵⁴The area under the study is more than 3,000 square kilometers.

and the budget constraint is

$$c_p + c_k + c_H + e_{educ} + a' \le a(1+r) + y_{parent} + y_{kid}$$
 (19)

Then household's maximization problem can be expressed in terms of aggregate consumption of a parent and a kid, i.e. $c \equiv c_p + c_k$, as

$$\max_{c,a,e_{educ}} U^{HH} = \frac{c^{1-\sigma}}{1-\sigma} \left[\lambda^{\frac{1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}} \right]^{\sigma}$$
(20)

and then the budget constraint is

$$c + c_H + e_{educ} + a' \le a(1+r) + y_p + y_k$$
 (21)

Derivation. Let μ be the Lagrange multiplier on the budget constraint, the FOC for parent and kid consumption are going to be:

$$\lambda c_p^{-\sigma} = \mu \implies c_p = \left(\frac{\lambda}{\mu}\right)^{\frac{1}{\sigma}}$$
$$(1-\lambda)c_k^{-\sigma} = \mu \implies c_k = \left(\frac{1-\lambda}{\mu}\right)^{\frac{1}{\sigma}}$$

Then

$$c \equiv c_p + c_k = \left(\frac{1}{\mu}\right)^{\frac{1}{\sigma}} \left[\lambda^{\frac{1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}}\right]$$
(22)

and hence

$$\mu = c^{-\sigma} \left[\lambda^{\frac{1}{\sigma}} + (1 - \lambda)^{\frac{1}{\sigma}} \right]^{\sigma}$$

Substituting into FOCs, we get:

$$c_p = \lambda^{\frac{1}{\sigma}} c \left[\lambda^{\frac{1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}} \right]^{-1}$$
(23)

and

$$c_k = (1-\lambda)^{\frac{1}{\sigma}} c \left[\lambda^{\frac{1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}} \right]^{-1}$$
(24)

Finally, replacing c_p and c_k in the household's maximization problem we get:

$$\max_{c,a,c_H} U^{HH} = \frac{c^{1-\sigma}}{1-\sigma} \lambda^{\frac{1}{\sigma}} \left[\lambda^{\frac{1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}} \right]^{\sigma-1} + \frac{c^{1-\sigma}}{1-\sigma} (1-\lambda)^{\frac{1}{\sigma}} \left[\lambda^{\frac{1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}} \right]^{\sigma-1}$$

Simplifying, we get

$$\max_{c,a,c_H} U^{HH} = \frac{c^{1-\sigma}}{1-\sigma} \left[\lambda^{\frac{1}{\sigma}} + (1-\lambda)^{\frac{1}{\sigma}} \right]^{\sigma}$$

Firm's Profit and Demand We start by looking at traditional entrepreneur with unbinding collateral constraint. Then we characterize choices of constrained traditional, following by unconstrained and constrained modern entrepreneur.

Traditional Entrepreneur maximizes his profit function

$$\max_{\{k,l\}} A_e z k^{\alpha} l^{\gamma} - w l - rk \tag{25}$$

where we omit the subscripts on α and γ to ease notation. The FOCs imply that

$$A_e z \alpha k^{\alpha} l^{\gamma} = rk \tag{26}$$

$$A_e z \gamma k^{\alpha} l^{\gamma} = w l \tag{27}$$

It thus follows that

$$k = \frac{\alpha}{\gamma} \frac{w}{r} l \qquad \Longrightarrow \qquad l = A_e z \gamma \left(\frac{\alpha}{\gamma} \frac{1}{r}\right)^{\alpha} w^{\alpha - 1} l^{\alpha + \gamma}$$
(28)

$$l^* = \left(A_e z \left(\frac{\gamma}{w}\right)^{1-\alpha} \left(\frac{\alpha}{r}\right)^{\alpha}\right)^{\frac{1}{1-\alpha-\gamma}}$$
(29)

$$k^* = \left(A_e z \left(\frac{\gamma}{w}\right)^{\gamma} \left(\frac{\alpha}{r}\right)^{1-\gamma}\right)^{\frac{1}{1-\alpha-\gamma}}.$$
(30)

Substituting into the profit function we find that

$$\pi_{T} = A_{e} z \left(A_{e} z \left(\frac{\gamma}{w} \right)^{1-\alpha} \left(\frac{\alpha}{r} \right)^{\alpha} \right)^{\frac{\gamma}{1-\alpha-\gamma}} \left(A_{e} z \left(\frac{\gamma}{w} \right)^{\gamma} \left(\frac{\alpha}{r} \right)^{1-\gamma} \right)^{\frac{\alpha}{1-\alpha-\gamma}} - w \left(A_{e} z \left(\frac{\gamma}{w} \right)^{1-\alpha} \left(\frac{\alpha}{r} \right)^{\alpha} \right)^{\frac{1}{1-\alpha-\gamma}} - (31)$$

$$-r\left(A_e z\left(\frac{\gamma}{w}\right)^{\gamma}\left(\frac{\alpha}{r}\right)^{1-\gamma}\right)^{\overline{1-\alpha-\gamma}} =$$
(32)

$$= (A_e z)^{\frac{1}{1-\alpha-\gamma}} \left(\frac{\gamma}{w}\right)^{\frac{\gamma}{1-\alpha-\gamma}} \left(\frac{\alpha}{r}\right)^{\frac{\alpha}{1-\alpha-\gamma}} - \gamma \left(A_e z \left(\frac{\gamma}{w}\right)^{\gamma} \left(\frac{\alpha}{r}\right)^{\alpha}\right)^{\frac{1}{1-\alpha-\gamma}} - \alpha \left(A_e z \left(\frac{\gamma}{w}\right)^{\gamma} \left(\frac{\alpha}{r}\right)^{\alpha}\right)^{\frac{1}{1-\alpha-\gamma}}$$
(33)

$$= (1 - \gamma - \alpha) \left(A_e z \left(\frac{\gamma}{w}\right)^{\gamma} \left(\frac{\alpha}{r}\right)^{\alpha} \right)^{\frac{1}{1 - \alpha - \gamma}}$$
(34)

For the constrained entrepreneur, the demand for capital will be such that the maximum amount of borrowing is achieved, or $k^* = \lambda_k a - P_c \mathbb{1}_{e=college}$ since the profit function is increasing in k up to its optimal level. This implies that constrained households face a trade-off between sending their kids to college and using more capital in production. Given that households can have less capital compared to an unconstrained entrepreneur, labor is adjusted accordingly, $l^* = \left(\frac{A_e z \gamma}{\omega} (k^*)^{\alpha}\right)$. Total profits are obtained by substitution of k^* and l^* .

Similarly, Modern Entrepreneurs maximizes his profit

$$\max_{\{k,l_H,l_L\}} A_e h k^{\alpha} (l_H^{\omega} l_L^{1-\omega})^{\gamma} - w_H L_H - w_L l_L - rk$$
(35)

The FOCs imply that

$$A_e h \alpha k^{\alpha} (l_H^{\omega} l_L^{1-\omega})^{\gamma} = rk \tag{36}$$

$$A_e h \gamma \omega k^{\alpha} (l_H^{\omega} l_L^{1-\omega})^{\gamma-1} \left(\frac{l_L}{l_H}\right)^{1-\omega} = w_h \tag{37}$$

$$A_e h \gamma (1-\omega) k^{\alpha} (l_H^{\omega} l_L^{1-\omega})^{\gamma-1} \left(\frac{l_L}{l_H}\right)^{-\omega} = w_L$$
(38)

(39)

Combining last two equations, we get that

$$l_L = \frac{w_H}{w_L} \frac{1 - w}{w} l_H \tag{40}$$

Defining $m \equiv \frac{l_L}{l_H} = \frac{w_H}{w_L} \frac{1-w}{w}$, we obtain

$$l_H^{\omega} l_L^{1-\omega} = m^{1-\omega} l_H \tag{41}$$

Substituting everything in FOCs

$$A_e h \alpha k^{\alpha} m^{(1-\omega)\gamma} l_H^{\gamma} = rk \tag{42}$$

$$A_e h \gamma \omega k^{\alpha} m^{(1-\omega)\gamma} l_H^{\gamma} = w_h l_H \tag{43}$$

$$A_e h \gamma (1-\omega) k^{\alpha} m^{(1-\omega)\gamma} l_H^{\gamma} = w_L l_L \tag{44}$$

(45)

Similar to traditional entrepreneur solving for optimal capital and labor we obtain

$$k^* = \left[A_e h m^{(1-\omega)\gamma} \left(\frac{\alpha}{r}\right)^{1-\gamma} \left(\frac{\gamma\omega}{w_H}\right)^{\gamma}\right]^{\frac{1}{1-\alpha-\gamma}},$$

or

$$k^* = \left[A_e h\left(\frac{\alpha}{r}\right)^{1-\gamma} \left(\frac{1-\omega}{w_L}\right)^{(1-\omega)\gamma} \left(\frac{\omega}{w_H}\right)^{\omega\gamma} \gamma^{\gamma}\right]^{\frac{1}{1-\alpha-\gamma}},\tag{46}$$

and

$$l_L^* = \left[A_e h\left(\frac{\alpha}{r}\right)^{\alpha} \left(\frac{1-\omega}{w_L}\right)^{1-\alpha-\omega\gamma} \left(\frac{\omega}{w_H}\right)^{\omega\gamma} \gamma^{1-\alpha} \right]^{\frac{1}{1-\alpha-\gamma}},\tag{47}$$

and

$$l_{H}^{*} = \left[A_{e}h\left(\frac{\alpha}{r}\right)^{\alpha}\left(\frac{1-\omega}{w_{L}}\right)^{(1-\omega)\gamma}\left(\frac{\omega}{w_{H}}\right)^{1-\alpha-\gamma(1-\omega)}\gamma^{1-\alpha}\right]^{\frac{1}{1-\alpha-\gamma}},\tag{48}$$

and, finally

$$\pi_M = (1 - \alpha - \gamma) \left(A_e h \left(\frac{\alpha}{r}\right)^{\alpha} \left[\frac{\omega\gamma}{w_L}\right]^{\omega\gamma} \left[\frac{(1 - \omega)\gamma}{w_H}\right]^{(1 - \omega)\gamma} \right)^{\frac{1}{1 - \alpha - \gamma}}.$$
(49)

If the maximum amount of capital available to the entrepreneur is $\bar{k} < k^*$, we have that labor is going to be optimized taking \bar{k} as given. This yields:

$$l_L^* = \left(\gamma A_e h \bar{k}^{\alpha} \left(\frac{1-\omega}{w_L}\right)^{1-\omega\gamma} \left(\frac{\omega}{w_H}\right)^{\omega\gamma}\right)^{\frac{1}{1-\gamma}}$$
(50)

$$l_{H}^{*} = \left(\gamma A_{e} h \bar{k}^{\alpha} \left(\frac{1-\omega}{w_{L}}\right)^{(1-\omega)\gamma} \left(\frac{\omega}{w_{H}}\right)^{1-(1-\omega)\gamma}\right)^{\frac{1}{1-\gamma}}$$
(51)

E Computational Algorithm

E.1 Steady State

The solution algorithm starts with guessing steady state level of prices, w_T^L , w_T^H , w_{NT}^L , w_{NT}^H , P_{NT}^H . Given the prices, solve the policy function for each set of state variables using value function iteration for each location. The process yields the optimal occupational and educational choices, including their locations, and policy functions for level of assets, consumption, capital, low- and high-skilled labor inputs for each location, as well as probability of residing in a given location.

Obtain the stationary distribution of households by finding fixed point using forward iteration given the policy functions for education and transition process for innate talent. Given the distribution and policy functions. obtain aggregate variables – low- and high-skilled labor demand and supply in each location, as well as housing demand and supply for non-Township. Check whether market clearing conditions for all the markets above are satisfied. Update the guess for prices and repeat until all markets clear.

Steady State During Apartheid. While the above computational algorithm is general for all periods, the race of the households enters the state variable for the Apartheid period. In other words, some the policy choices are limited for Blacks and Whites, and, hence, value function iteration step has to be performed for each race separately.

E.2 Transitional Dynamics

To compute the transitional dynamics of our model we proceed as follows. First, we compute the two steady states: under Apartheid and race-blind as described above. In both steady states, we obtain a

density over the states $\mathcal{F}_{i,r}^{ss}(a, z_p, z_k, h_p)$ with $i \in \{\text{Apartheid}, \text{Race Blind}\}\ \text{and}\ r \in \{\text{Black}, \text{White}\}\)$. Under Apartheid, this distribution is different for Whites and Blacks. In the race-blind, it is the same.

Our algorithm proceeds along the lines of Heer and Maussner (2005):

- 1. Guess the length *T* of the transition.
- 2. We initialize the economy at time 1 endowing it with the density of the Apartheid steady state
- 3. Construct an initial guess of the sequence of equilibrium prices along the transition, P^t = (w_T^L, w_T^H, w_{NT}^L, w_{NT}^H, P_{NT}^H). We do so assuming that households in the last period forecast that prices remain constant going forward, while updating the density over states F^t_{i,t} in each period according to their policy function. The price at time T + 1 is that of the race-blind equilibrium, and so is the distribution over states.
- 4. Backward iteration. At time *T*, we compute the optimal decision functions using as prices our guess for P^T and that we know that prices at T + 1 and value functions are those of the Race-blind steady state. After having done that, we go to time T 1, and we compute the optimal decision functions given the guesses (P^T , P^{T-1}), and so forth.
- 5. Given the initial distributions, $\mathcal{F}^{ss}_{\text{Apartheid},r}(a, z_p, z_k, h_p)$, we simulate forward the dynamics of the distribution \mathcal{F}^t_r given the policy functions we have computed for each period in the point above. We compute aggregate labor and housing demand and supply along the transition.
- 6. Check whether market clearing conditions for all the markets above are satisfied. Update the guess for prices for each period along the transition path and repeat until all markets clear.
- 7. Check whether *T* is large enough by trying a larger *T* and see if the equilibrium path is robust.

F Model Quantification: Additional Results

Period	Description
1900 - 1922 Early seg- regation (Emergence)	First Townships (called 'locations') emerge some within towns (on a mixed race basis) but increas- ingly over time on the outskirts of towns. They are allowed by Government so as to ensure a labour force in urban areas but limited investment is made into their development. Living conditions are extremely poor. Influx control is applied to regulate labour supply for farmers and mines. Africans excluded from rights (political and land). Segregation is applied by government but on a frag- mented and decentralized basis. Civil society begins to emerge to contest segregation and living conditions.
1923 – 1947 Segregation consolidated (Adoption)	Townships assume increasing importance in urban areas as the reliance on African labour in- creases. Investment by Government in Townships increases but is still not able to keep up with demand due to high levels of urbanization. As a result informal settlements emerge and living conditions remain poor. Relocation of Africans commences. Central Government takes on a more direct role in regulating the nature of Townships through oversight and funding. Civil society increases resistance activities using deputations and petitions. The potential to mobilize in Town- ships emerges, as does the use of strikes and boycotts.
1948 - 1975 Apartheid (Control)	Initially there is extensive development of Townships by Government – despite this informal set- tlements and overcrowding increases. From 1960 development slows down as the focus shifts to Homeland development. Townships are segregated physically, socially and economically from towns and residents become progressively isolated and poorer as access to economic opportunities and urban amenities are restricted. Civil society becomes increasingly militant. International sanc- tions and boycotts are applied.
1976 - 1993 Apartheid dismantled (Resistance)	Civil unrest, international sanctions, increasing urbanization and a declining economy contribute to the dismantling of apartheid policy. There is increasing acceptance that Africans will remain per- manently in urban areas and 99 year leasehold and full property rights are provided respectively. Funding for housing is increased and extensive private sector housing development in Townships commences. Racial Local Authorities are established but are dysfunctional. Africans are no longer restricted to living only in Townships and start moving into the inner city and suburbs. South Africa is left with cities structured by apartheid. Townships are characterized by small, poor qual- ity houses, with a large number of informal settlements, poor service infrastructure and amenities and lack of affordable public transportation.
1994 – 2004 Democratisation (Upgrading)	Local Authorities undergo substantial transformation resulting in constraints in respect of capacity and processes. Significant investment into Townships occurs through the Special Integrated Presi- dential Projects (SIPPs) and Urban Renewal Programme (URP) launched in 2001 as a ten year pilot programme and sectoral initiatives. Success is variable and impact limited. Access to housing, ser- vices and amenities improves but Townships remain separate and marginalized. A key difficulty that persists is capacity and coordination across and within spheres of government. South Africa reflects 'two economies in one country' – one white and wealthy (formal-first economy), the other overwhelmingly black and poverty stricken (informal-second economy). Townships fall into the latter.
2004-2009 Towards urban in- tegration (Inclusion)	The URP continues to be implemented – Provinces and Municipalities start replicating the method- ology but funding and capacity remain key constraints. Implementation of the sectoral pro- grammes impacts positively on Townships. However upgrading of Townships continues to be largely uncoordinated. Better and more comprehensive planning and budgeting is pursued (through IDPs and the National Spatial Development Perspective. The Neighbourhood Develop- ment Partnership Programme is launched in 2006. The Housing Development Agency with a focus on integrated human settlements is launched in 2009. Townships still remain marginalised and isolated within towns and cities. The emphasis of development initiatives in Townships gradually shifts to a recognition of the critical need for integration of Townships into towns and cities. The role of Local Government in respect of the development of Townships remains unresolved, with a greater devolution of responsibility towards Local Government but generally with inadequate authority, capacity and funding. There is increasing recognition of the role of the private sector in developing Townships. However tensions remain around the impact on existing Township busi- ness interests. 67

Table B3: Development of Townships: Timeline